LMSC-D152635

SERIES 1

25 FEBRUARY 1972

CR 115486

SHUTTLE/AGENA STUDY

FINAL REPORT

PREPARED FOR
THE NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS

CONTRACT NAS9-11949

LMSC
SPACE SYSTEMS
DIVISION

ANNEX B

CATALOG OF EXISTING FLIGHT EQUIPMENT

LOCKHEED MISSILES & SPACE COMPANY, INC.
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

25 February 19[illegible]

LMSC-D152635
Series 1

SHUTTLE/AGENA STUDY FINAL REPORT

Annex B
CATALOG OF EXISTING FLIGHT EQUIPMENT

Submitted to the
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

LOCKHEED MISSILES & SPACE COMPANY, INC.
A Subsidiary of Lockheed Aircraft Corporation
Sunnyvale, California

FOREWORD

Annex B contains supplemental data pertinent to the Shuttle/Agena Study Final Report. Although not required under Contract NAS9-11949, this background information on existing flight hardware should prove helpful in any evaluation of Agena capabilities for the proposed space tug missions. It is therefore included as a useful adjunct to the Final Report.

PRECEDING PAGE BLANK NOT FILMED

CONTENTS

INTRODUCTION

The National Aeronautics and Space Administration, along with other government agencies, has been studying the feasibility of using expendable third stages with the space shuttle on missions for which a reusable tug is either not available or not cost effective. The Space Shuttle/Agena Space Tug Compatibility Study conducted by Lockheed Missiles & Space Company, Inc., under Contract NAS 9-11949 for the Manned Spacecraft Center, Houston, Texas, identified significant Space Shuttle/Agena interface areas and established the preliminary design and operational capability of an Agena Space tug vehicle for such applications.

The Agena space tug design was based on the requirements of representative reference missions, the use of existing hardware, and the experience gained from more than 300 Agena flights. To provide a convenient reference for understanding the Agena tug design selection or for evaluating alternative concepts, this catalog of existing flight equipment was prepared. Equipment descriptions are grouped by Agena subsystem, as follows:

1 Spaceframe
2 Propulsion
3 Electrical
4 Guidance and Flight Controls
5 Telemetry, Tracking, and Command

These systems, most of which have been flight qualified on prior Agena programs, permit specialized mission requirements to be satisfied without sacrificing cost or reliability.

Section 1
SPACEFRAME SYSTEM

Section 1
SPACEFRAME SYSTEM

1.1 BASIC VEHICLE SPACEFRAME SYSTEM

The basic Agena spaceframe system (Fig. 1-1) consists of three major structural sections: the forward section, the propellant tank section, and the aft section. Together, they provide for the installation of basic and mission peculiar equipment, for the storage of propellants, and for structural support of the payload.

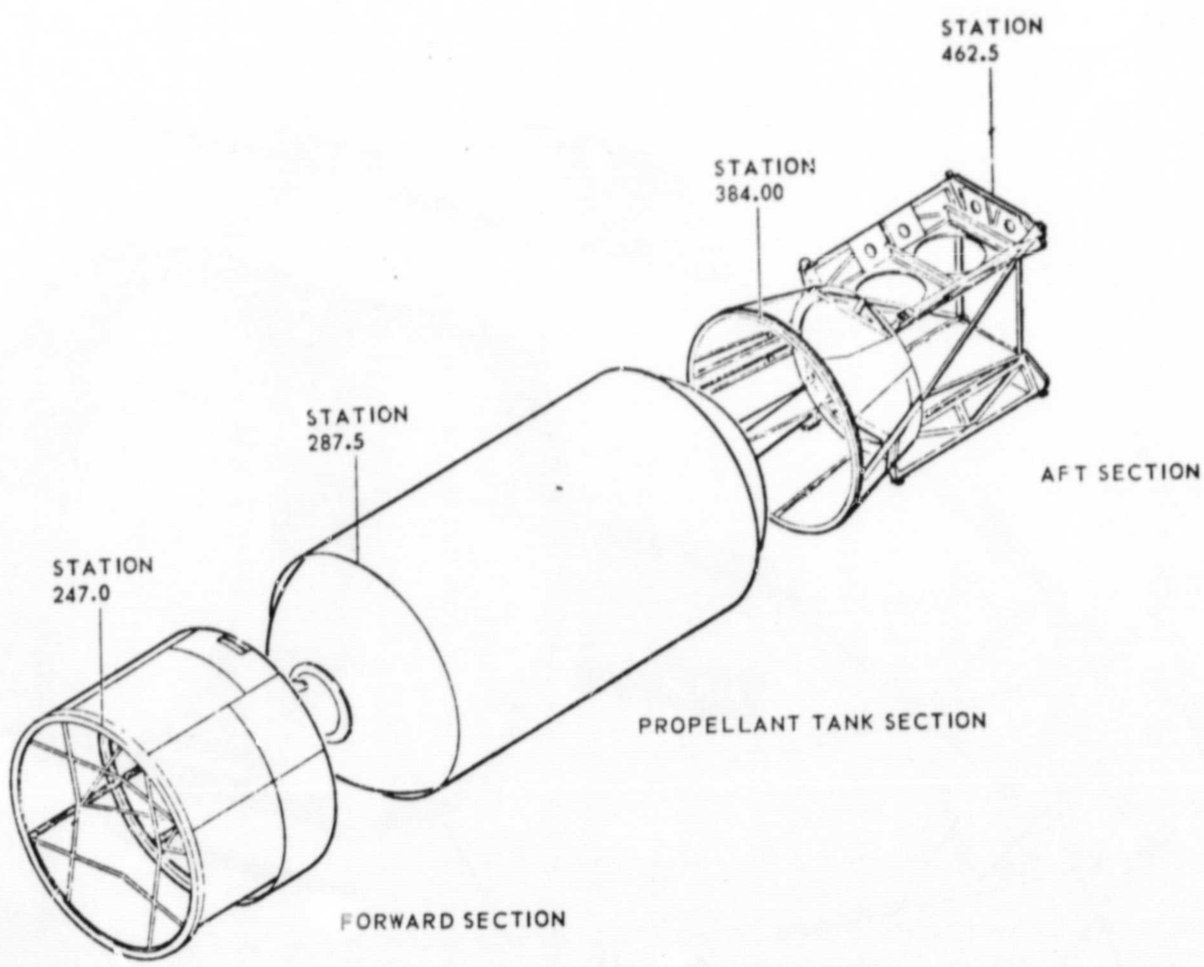


Fig. 1-1 Basic Spaceframe System

1.1.1 Forward Section Structure

LMSC Drawing Number: 1389608
LMSC Specification Number: None
Vendor: Built in-house by LMSC

The forward section structure (Fig. 1-2) is 40.5 inches long, extending from station 247.0 to station 287.5. The section is a semimonocoque structure utilizing internal rings and longitudinal members covered by a fixed skin and removable access door. Within the forward section, a truss-type tubular aluminum frame provides additional strength and facilitates the mounting of equipment. The fixed skins and the access doors are fabricated from beryllium. A payload mounting ring is located at station 247.0, the front end of the forward section. The ring contains eight equally spaced 1/2-inch holes for payload mounting.

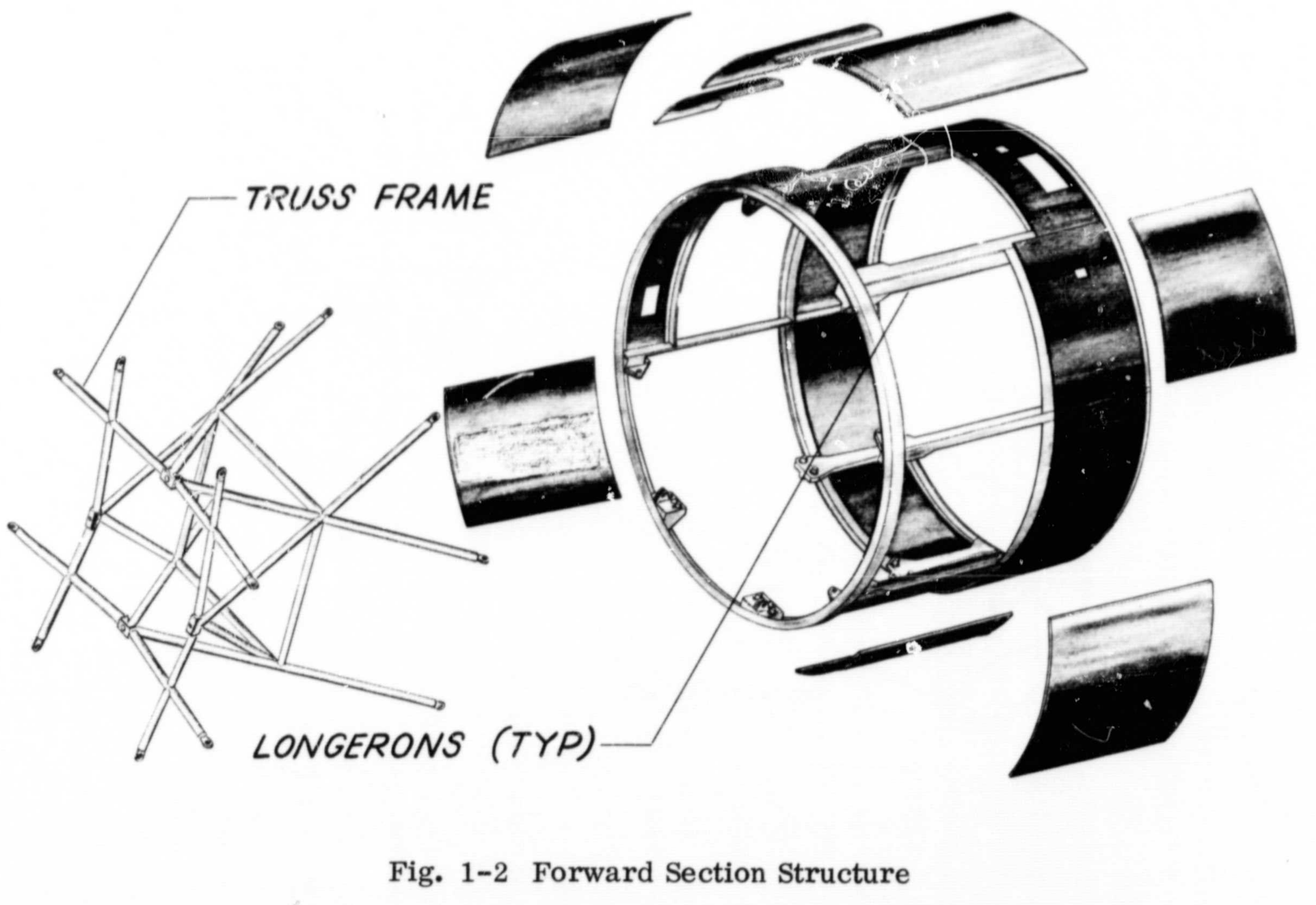


Fig. 1-2 Forward Section Structure

1.1.2 Propellant Tank Assembly

LMSC Drawing Number: 1398005
LMSC Specification Number: 1414819
Vendor: Built in-house by LMSC

The propellant tank assembly (Fig. 1-3) consists of a fuel tank and an oxidizer tank, with a common bulkhead. The assembly is an integral part of the vehicle spaceframe and provides the supporting structure and exterior surface of the center portion of the vehicle. A containment and scavenging system mounted on the aft portion of each tank includes sumps and screens to control propellant orientation during flight. Maintaining the propellants in the desired orientation assures the engine of the supply required for starts in space.

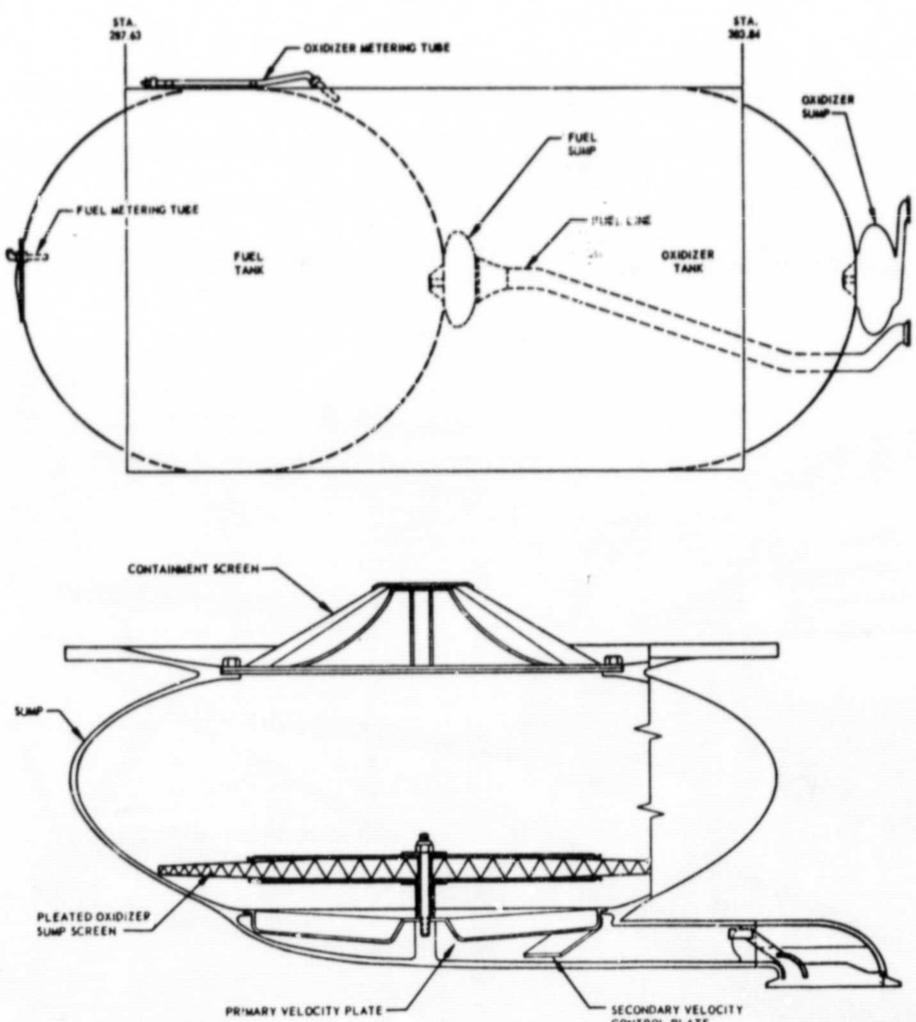


Fig. 1-3 Propellant Tank and Propellant Sump Detail

1.1.3 Aft Section Structure

LMSC Drawing Number: 1389609
LMSC Specification Number: None
Vendor: Built in-house by LMSC

The aft section structure (Fig. 1-4) consists of the engine thrust cone and the aft equipment rack joined into a single assembly. The section provides support for the rocket engine and facilities for mounting basic and mission peculiar equipment.

The engine thrust cone contains a mating ring, which connects the aft section to the propellant tank, and an engine mounting ring, to which the engine and aft equipment rack are connected at Station 411.86. Longitudinal members connect the mating ring to the engine mounting ring and form a truncated cone.

The equipment rack portion of the aft section consists of four truss frames, which are cantilevered from the engine cone and extend to the aft bulkhead at Station 462.5. The truss frames and bulkhead sections are structurally augmented by a tubular framework, which provides the necessary lateral and longitudinal reinforcement.

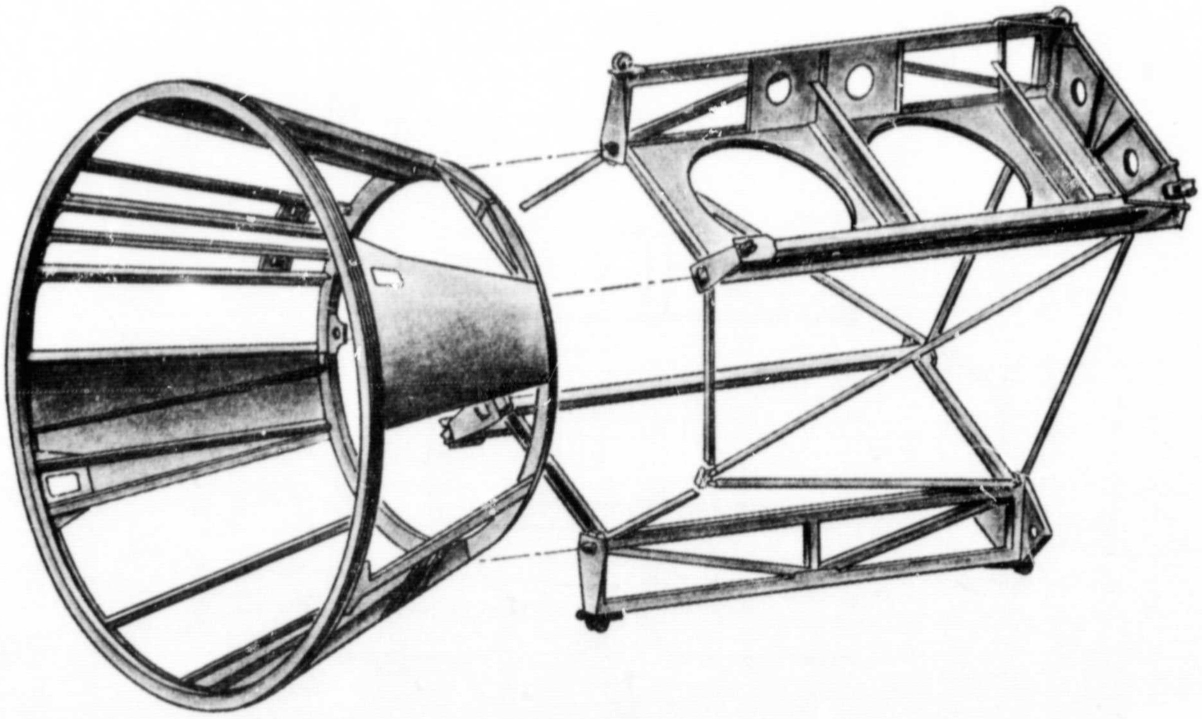


Fig. 1-4 Aft Section Structure

1.2 MISSION-PECULIAR SPACEFRAME EQUIPMENT

1.2.1 Aft Structure Kit

LMSC Drawing Number: 1398356
LMSC Specification Number: 1414908
Vendor: Built in-house by LMSC

Left and right aft structure kits can be used to increase the capability of installing mission peculiar equipment in the aft section. Each kit includes a web assembly, a beam assembly, and attaching hardware. These kits are typically used for mounting solar arrays, secondary payloads, secondary propulsion systems, and additional attitude control gas tanks.

1.2.2 Engine Cone Auxiliary Structure Kit

LMSC Drawing Number: 1396330
LMSC Specification Number: 1414597
Vendor: Built in-house by LMSC

This kit provides the added structural reinforcement required to permit mounting of additional equipment on the aft equipment rack. An extra 1000 pounds of mission-peculiar equipment may be added to the aft rack when this kit has been incorporated.

1.2.3 Auxiliary Forward Equipment Racks

Numerous auxiliary forward equipment racks have been used with Agena vehicles in mission peculiar applications. Figures 1-5 and 1-6 show two such auxiliary racks typical of the many flight-proven and qualified designs which can be adapted to satisfy a wide variety of mission requirements.

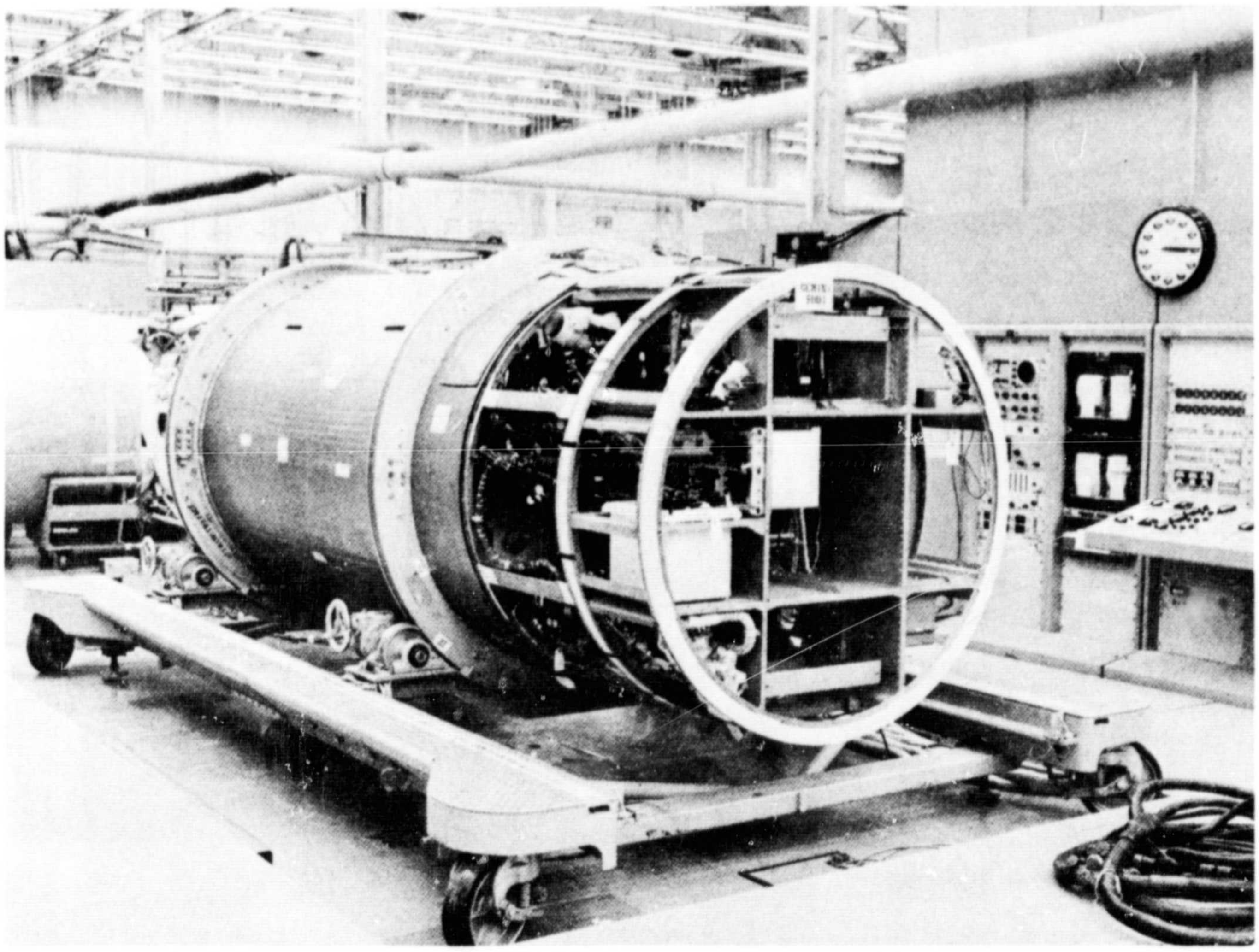


Fig. 1-5 Gemini Agena Auxiliary Forward Section

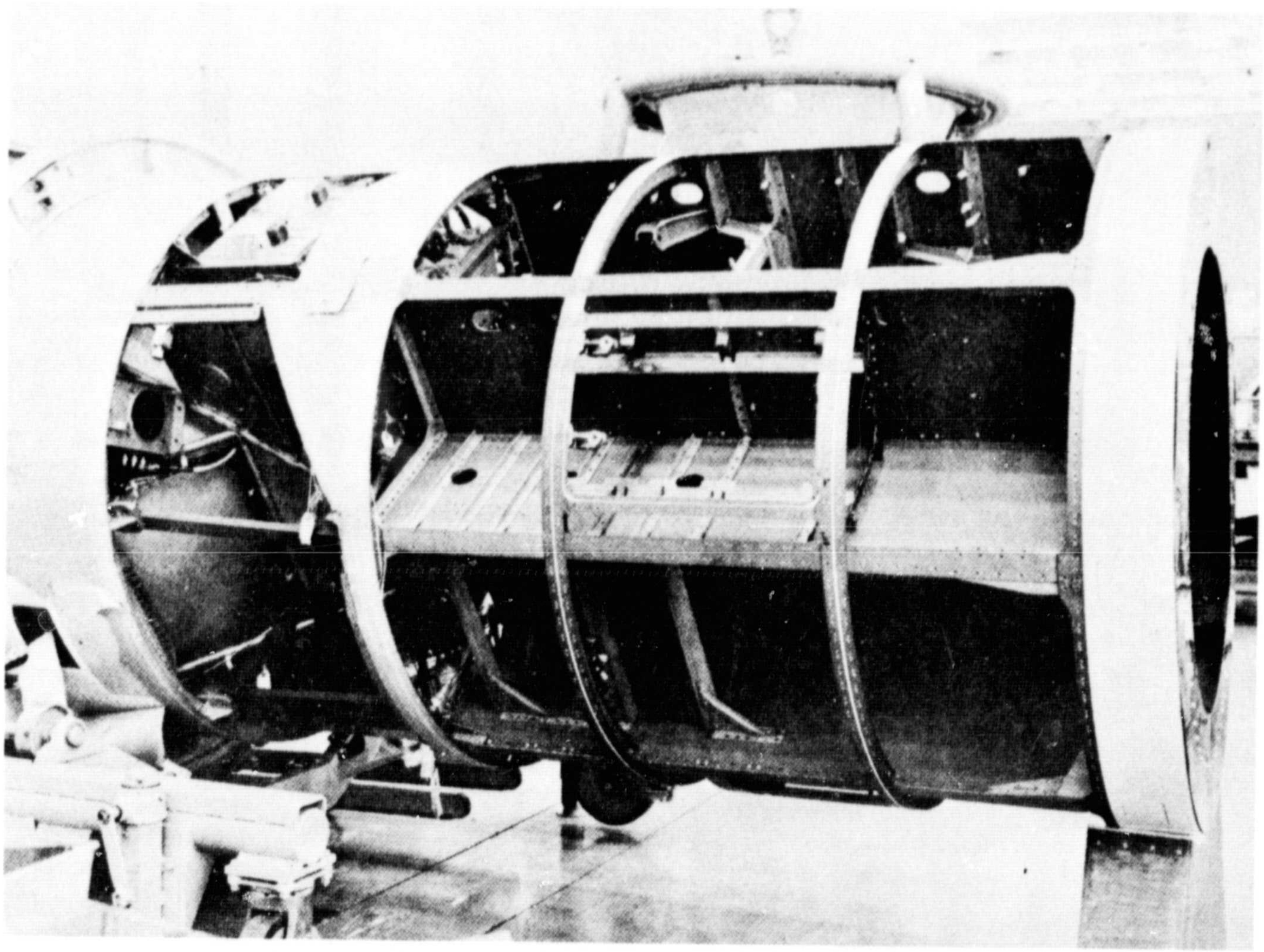


Fig. 1-6 Snapshot Auxiliary Forward Section

Section 2
PROPULSION SYSTEM

Section 2
PROPULSION SYSTEM

2.1 BASIC VEHICLE PROPULSION SYSTEM

The propulsion system for the basic Agena tug, shown schematically in Fig. 2-1, consists of a rocket engine, a pressurization system, a propellant feed, load and vent system, and a passive propellant orientation system. The propulsion system uses unsymmetrical dimethyl hydrazine (UDMH) for fuel and inhibited red fuming nitric acid (IRFNA) for oxidizer. High-pressure helium is used to pressurize the propellants.

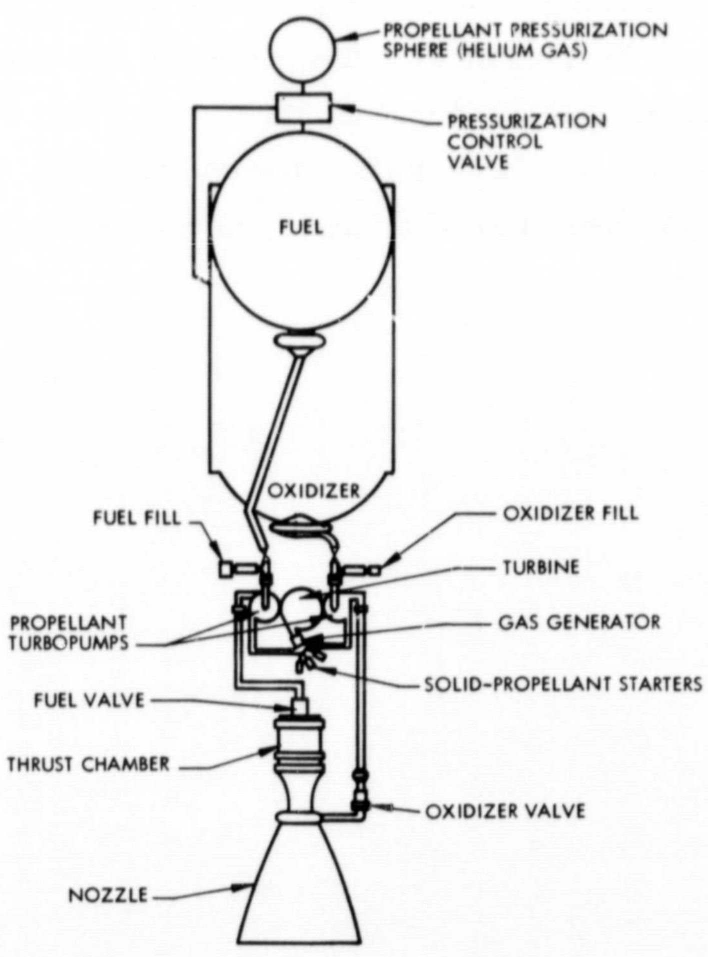


Fig. 2-1 Basic Propulsion System

The propellant pressurization components regulate and distribute high-pressure gas, maintaining pressure in the tanks which forces propellants into the engine pump inlets to prevent cavitation. The pressurization system is a "blowdown type," in which the flow of helium gas from the high-pressure storage tank to the propellant tanks is controlled by fixed orifices. The resulting pressure profile supports a positive pump inlet pressure requirement and assures a higher pressure on the forward side of the common propellant tank bulkhead.

The zero-gravity environment and the varied acceleration disturbances resulting from control torques and atmospheric drag between burns make the propellants tend to separate and intermix with the pressurization gas. The propellant containment and scavenging sumps, by trapping a quantity of propellants and controlling their flow, supply gas-free propellants until propellant reorientation can occur after ignition. Each sump contains a screen with accurately sized holes; surface tension at the screen retains the propellants in the sumps. Each sump also has a pleated screen and a propellant velocity control plate to suppress surface dip tendency that could result in gas injection by the pumps and engine shutdown. The screens and the control plate function with the sump geometry to assure smooth propellant feed and to minimize residual and unused propellants.

2.1.1 Rocket Engine

LMSC Drawing Number: 1462391
LMSC Specification Number: 1420138
Vendor: Bell Aerosystems Company

The Agena rocket engine (Fig. 2-2) is a Bell Aerosystems Company Model 8096 (USAF designation YLR 81-BA-11) that is turbopump fed with liquid propellants. The engine has a single combustion chamber, which is regeneratively cooled by oxidizer that passes through drilled passages in the thrust chamber walls and throat prior to entering the injector, and the expansion nozzle is cooled by radiation. The engine is mounted in a gimbal ring that allows the engine thrust vector to be varied for pitch and yaw control during engine operation. Hydraulic actuators supply the motive force for thrust chamber movement in response to signals sent by the ascent guidance system.

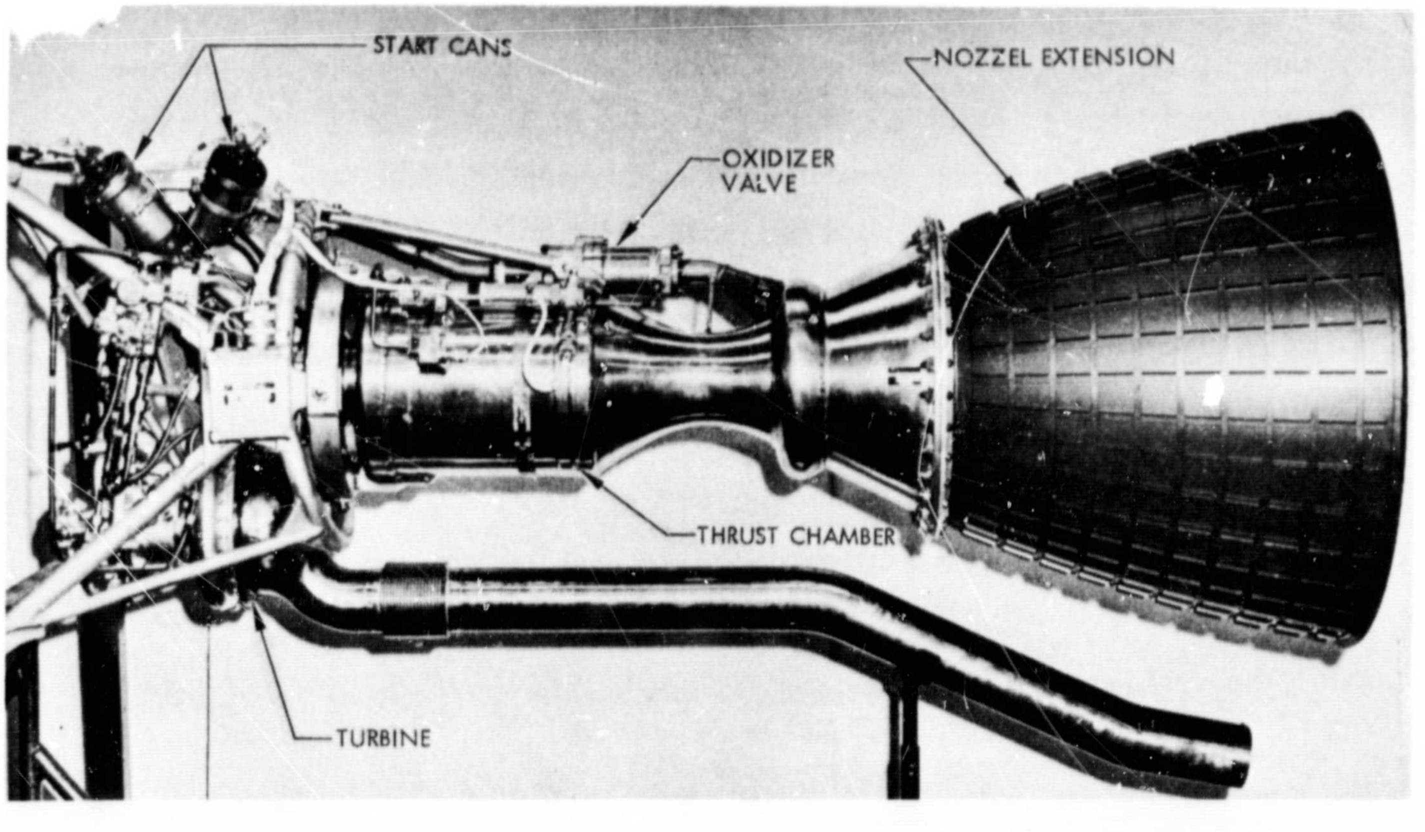


Fig. 2-2 Model 8096 Rocket Engine

The propellant pumps are geared to a single turbine, driven by gases from a gas generator in which the propellants are reacted in a fuel-rich mixture ratio. A duct installed along the engine nozzle exhausts the turbine gases overboard.

The engine performance parameters of thrust, mixture ratio, and specific impulse are closely controlled by cavitating venturis in the pump manifolds and in the gas generator flow circuit.

The main propellant valves are incorporated in the engine. The oxidizer valve is spring loaded; it is operated directly by the oxidizer pressure buildup or decay. The fuel valve is also spring loaded; however, its operation by fuel pressure is controlled by a solenoid valve that actuates when oxidizer pressure builds up.

Engine start is initiated by a single command signal energizing the gas generator solenoid valve and igniting a solid-propellant start cartridge that provides sufficient hot-gas flow to the turbine until pump action makes the system self-sustaining. From one to three start cartridges can be installed, providing for single to triple start capability. Engine shutdown is initiated by closure of the gas generator and fuel solenoid valves when their electrical power is terminated. As the gas generator turbine slows, oxidizer pressure decays and the oxidizer valve then closes. The start and shutdown sequences ensure that oxidizer flow precedes and overlaps fuel flow for reliable operation. A single-operation, fast-shutdown oxidizer valve kit is available as an option for reducing the oxidizer post flow loss on multiple burn missions. This kit uses a small volume of compressed gas to close the oxidizer valve quickly prior to oxidizer pressure reduction.

2.1.2 Pyro-Operated Helium Control Valve

LMSC Drawing Number: 1393028

LMSC Specification Number: 1414804

Vendor: Built by Prosser Industries, to an LMSC design

The pyro-operated helium control valve (Fig. 2-3) is a squib-actuated valve. The valve isolates the propellant tanks from the high-pressure helium gas in the helium sphere. It is opened during first engine operation to permit pressurization of the propellant tanks. Internal orifices in the valve control the helium gas flow. Operation of the valve is as follows:

a. First Actuation. At 1.5 seconds (nominal) after the engine start signal, a squib function provides pressure to open the helium control valve and allow helium to flow through orifices between the helium supply sphere and the oxidizer and fuel tanks. The actuation of the PHCV also serves to isolate the helium fill quick-disconnect and the fuel and oxidizer vent quick-disconnect couplings from the rest of the system, preventing tank leakage through the quick-disconnects.

b. Second Actuation. At some discrete time (about 350 seconds) after the initial opening of the helium control valve, a second set of squibs is fired, isolating the oxidizer tank from all other ports and passages of the PHCV. At this time, only the helium supply and the fuel tank pressurization ports are open and common.

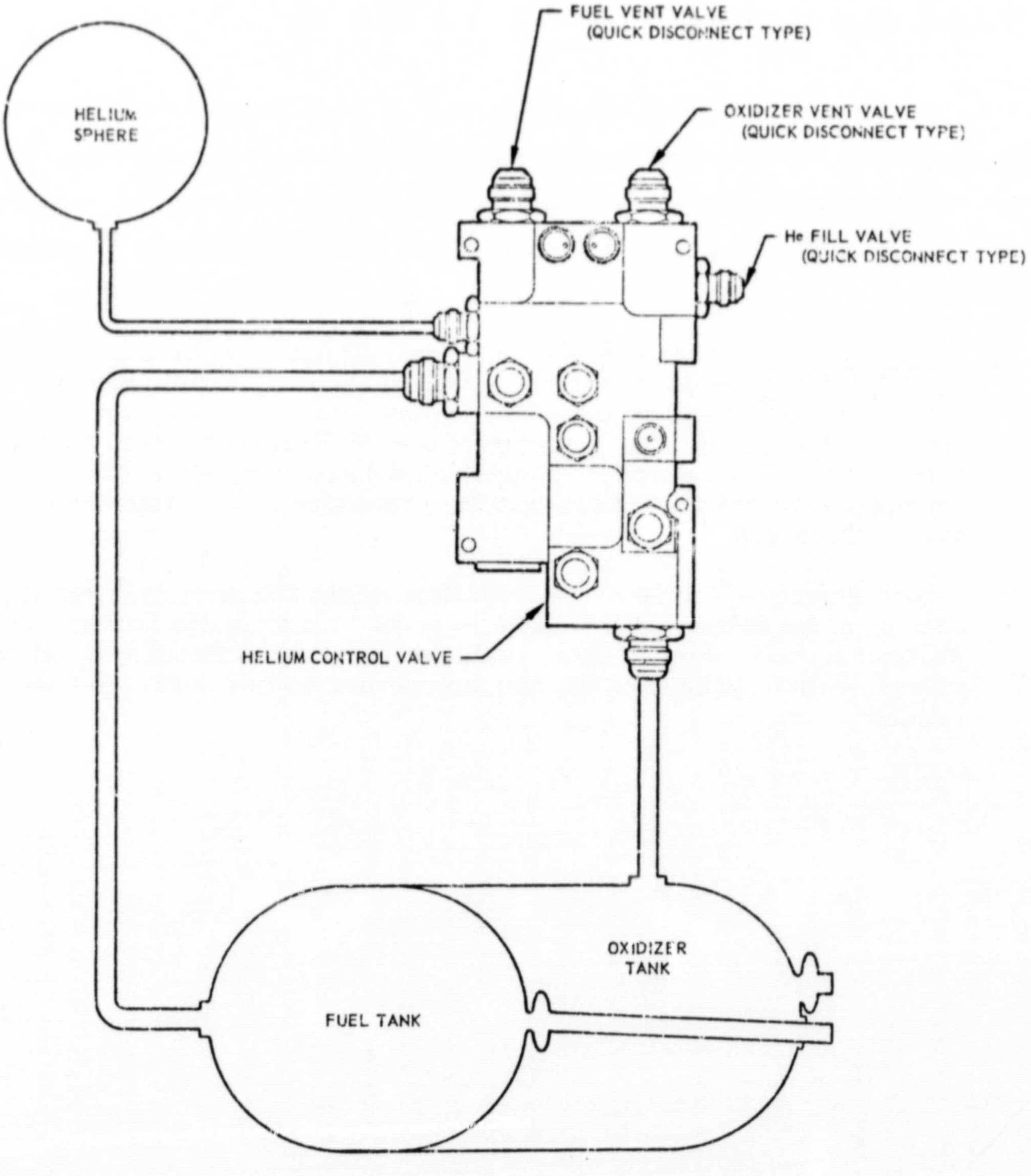


Fig. 2-3 Pyro-Operated Helium Control Valve

2.1.3 Helium Storage Sphere

LMSC Drawing Number: 1464743

LMSC Specification Number: 1417364

Vendor: Airtek

The helium storage sphere is constructed of titanium alloy; it has a capacity of 1612 cubic inches and a maximum operational pressure of 3600 psi. The sphere supplies pressurization gas to the propellant system through the pyro-operated helium control valve. The sphere is installed in the forward section of the vehicle.

2.1.4 Helium Fill Coupling

LMSC Drawing Number: 1381302
LMSC Specification Number: 1419693
Vendor: Built in-house by LMSC

The helium fill coupling is a quick-disconnect type used to connect external equipment for filling the helium supply sphere prior to flight. The airborne half is self sealing, and closes when the umbilical is disconnected.

2.1.5 Propellant Fill and Vent Couplings

LMSC Drawing and Specification Numbers and Vendors:

	Drawing	Specification	Vendor
Fuel Fill Coupling	1062532	1067287	Schulz
Oxidizer Fill Coupling	1460757	1418428	Schulz
Vent Couplings	1381289	1419692	LMSC

The propellant fill and vent couplings are quick-disconnect couplings, which are used to load propellants from the propellant transfer equipment on the ground and to dump propellants in the event of an abort. Both the vent and fill couplings of each tank are connected to the transfer equipment during loading and unloading, each pair thus forming a closed loop.

2.1.6 Bellows and Strainers

LMSC Drawings and Specification Number and Vendors:

Nomenclature	Drawing	Specification	Vendor
Fill Bellows	1462532	1420655	Flexible Metal Hose Mfg. Co.
Ox. Feed Bellows	1461967	1414806	Fairchild
Fuel Feed Bellows	1462529	1420654	Flexible Metal Hose Mfg. Co.
Alternate Bellows	1461986	1414806	Fairchild
Alternate Bellows	1461987	1414806	Fairchild
Strainer	1461310	1067001	Acoustica Associates Inc.
Strainer	1387372	–	LMSC

The fuel fill line and bellows and the oxidizer fill line and bellows are similar in appearance and function, but they are not interchangeable. Both are straight-line, flexible-hose assemblies, with a bellows section inserted between the two rigid metal ends. The bellows also accommodate slight misalignments in the lines. The outboard ends of both the lines and the bellows assemblies are flanged for bolting to the underside of the respective quick-disconnect fill couplings. The inboard ends of the assemblies are flared and held to the mating assemblies by clamps. Cone-shaped strainers are inserted in the lines to prevent passage of foreign particles. Bellows protectors are provided to encase the bellows during ground handling operations. These protectors are removed before launch. The feed bellows are located between the propellant tanks and the engine. Their function is identical to that of the fill bellows, except that the feed bellows also isolate engine vibration from the propellant tanks.

2.1.7 Propellant Isolation Valves

LMSC Drawing Number: 1463144
LMSC Specification Number: 1415273
Vendor: Whittaker

The propellant isolation valves (Fig. 2-4) are motor-driven blade valves incorporated into the system to prevent pump seal leakage during long coast periods and to prevent propellant boiloff from affecting engine restart. The valves are used in the open position for filling, draining, and flushing the propellant tanks through an integral fill port. In the closed position, the valves isolate the turbopump and fill lines from the propellant tanks and vent residual propellants through an integral vent port that opens only after the valve is fully closed. The valves are actuated from open to closed or from closed to open by an integral electrical motor that de-energizes itself at the fully open and fully closed positions. When the motor is energized, it drives a planetary gear train that is connected to a shaft. The shaft's rotary motion is converted to linear motion by an arm, one end of which is fixed to the shaft while the other end slides in a horizontal slot in the blade. The free end of the arm moves through an arc while retained in the slot; this action forces the blade to move in a vertical direction so that it slides against the main seal retained in the valve body. The blade's sliding action opens and closes the propellant flow. The venting mechanism opens only after the valve blade has fully closed off the flow area and closes before the valve blade opens to allow propellant flow.

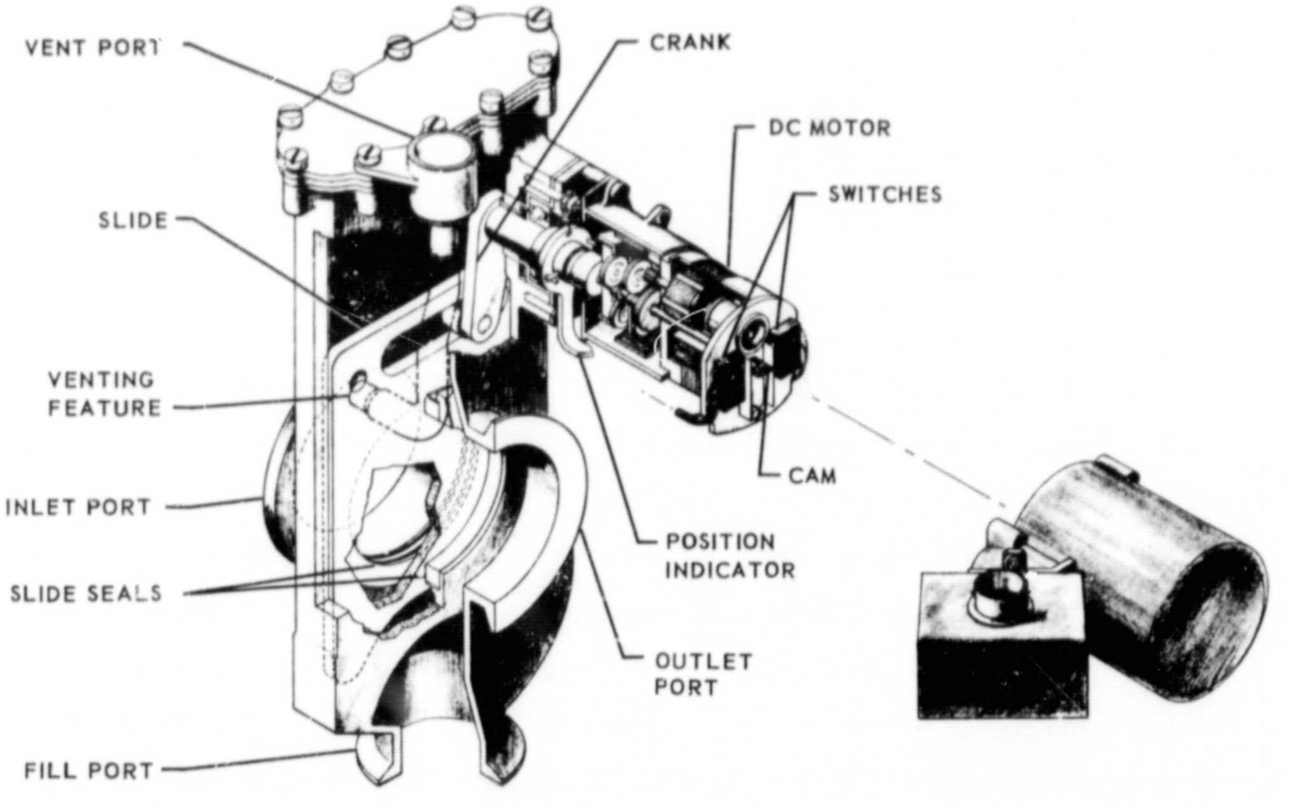


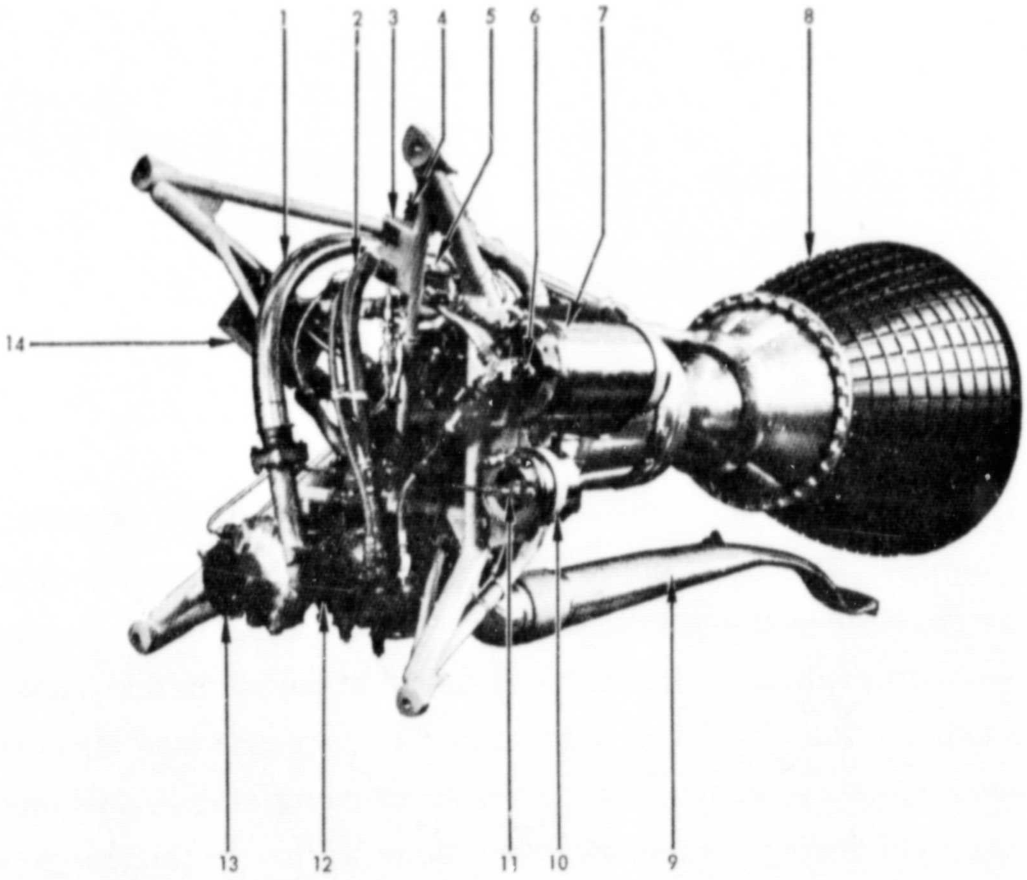
Fig. 2-4 Propellant Isolation Valve

2.2 MISSION-PECULIAR PROPULSION EQUIPMENT

2.2.1 Multistart Rocket Engine

LMSC Drawing Number: 1461969
LMSC Specification Number: 1414829
Vendor: Bell Aerosystems Company

Bell Aerosystems Company Model 8247 Rocket Engine (USAF designation XLR-81-BA-13) can be used in place of the basic Model 8096 engine for missions requiring more than the three starts possible with the basic engine. This engine was developed and flown on the Gemini Agena Program and differs from the 8096 engine in that separate gas generator valves are used on the 8247 engine and that the start cans and associated components used on the 8096 engine are replaced by start tanks containing UDMH and IRFNA. The engine is started by allowing start-tank propellants to flow to the gas generator where hypergolic reaction takes place. The generated gas drives the turbine, which in turn drives the oxidizer pump and fuel pump. These pumps supply the thrust chamber and gas generator with propellants and, after each start, recharge the start tanks. The 8247 engine is shown in Fig. 2-5.



1. OXIDIZER MANIFOLD
2. FUEL MANIFOLD
3. ENGINE ELECTRICAL INTERFACE CONNECTORS
4. GAS GENERATOR FUEL SOLENOID VALVE
5. GAS GENERATOR OXIDIZER SOLENOID VALVE
6. FUEL FILL AND DRAIN VALVE
7. FUEL START TANK
8. THRUST CHAMBER NOZZLE EXTENSION
9. TURBINE EXHAUST DUCT
10. OXIDIZER START TANK
11. OXIDIZER FILL AND DRAIN VALVE
12. FUEL PUMP
13. OXIDIZER PUMP
14. ELECTRONIC GATE

Fig. 2-5 Model 8247 Rocket Engine

2.2.2 Propellant Dump Kit

LMSC Drawing Number: 1398339

Installation of the propellant dump kit provides a means of jettisoning resignal propellants while in orbit. Dumping of propellants may be necessary to prevent vehicle attitude disturbances due to leakage of residual propellants or propellant slosh. The dumping is accomplished by opening squib-operated valves to permit liquid expulsion and the venting of pressurized gas through tubes attached to the propellant tank feed lines near the engine pump inlets. The oxidizer dump valve is opened first to assure the absence of undesirable pressures on the common bulkhead from the oxidizer tank side. Shortly after the oxidizer dump valve is opened, the fuel dump valve is opened. The opening of the valve vents all propellants and gases from the propulsion system.

2.2.2.1 Propellant Dump Valve.

LMSC Drawing Number: 1461421
LMSC Specification Number: 1412507
Vendor: Pyrodyne, Inc.

This unit (Fig. 2-6) is a normally closed, squib-operated valve with 3/4-16 MS inlet and outlet fittings and provisions for two M-11 squibs.

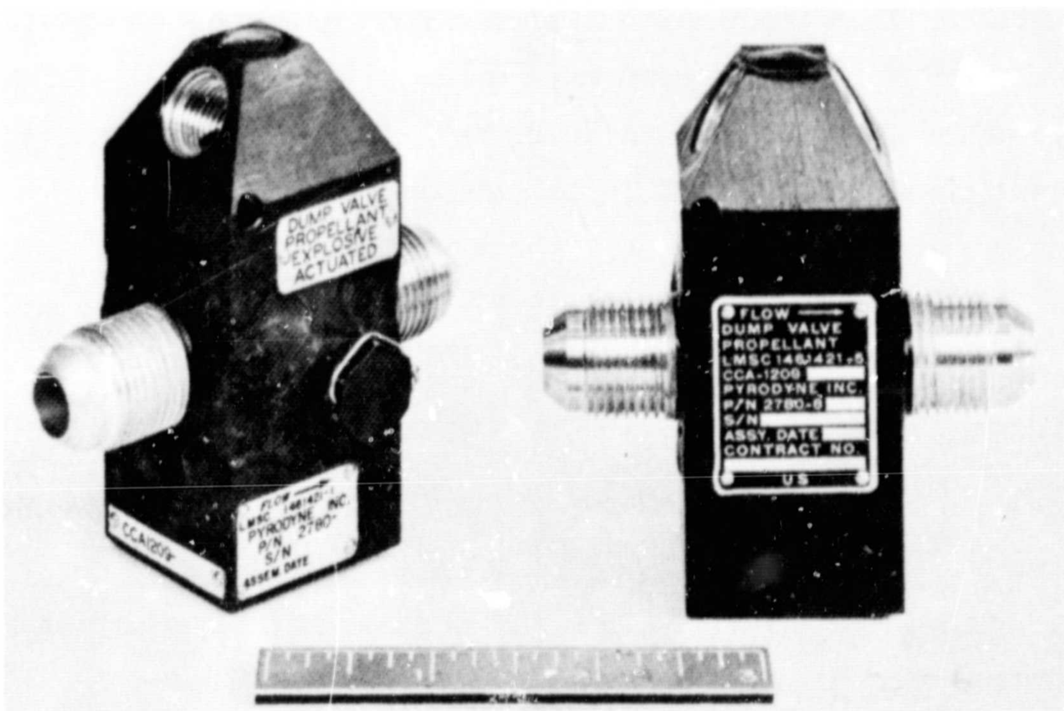


Fig. 2-6 Propellant Dump Valve

2.2.3 Secondary Propulsion Systems (SPS)

Several different secondary propulsion systems have been used with Agena vehicles for drag makeup, orbit adjust, and deboost. Two such systems are currently used on Agena programs – one a Rocketdyne system utilizing liquid propellants, and the second system utilizing a cluster of solid rockets. A third secondary propulsion system, also utilizing liquid propellants, was developed and flown on the Gemini Agena Program.

2.2.3.1 Rocketdyne Secondary Propulsion System.

LMSC Drawing Number: 1462607

LMSC Specification Number: 1421027

Vendor: Rocketdyne Division of North American Rockwell

The Rocketdyne SPS is shown schematically in Fig. 2-7. The system, mounted in two modules on the aft equipment rack, includes two propellant tanks, a pressurization system, and two thrust chamber assemblies. Characteristics of the system follows:

Characteristic	Value
Thrust	200.0 lb (100.0 lb/engine)
Nominal Total Impulse	80,800 lb-sec
Dry Weight	92.0
Loaded Weight	400.0 lb
Fuel	Monomethylhydrazine
Oxidizer	Nitrogen Tetroxide

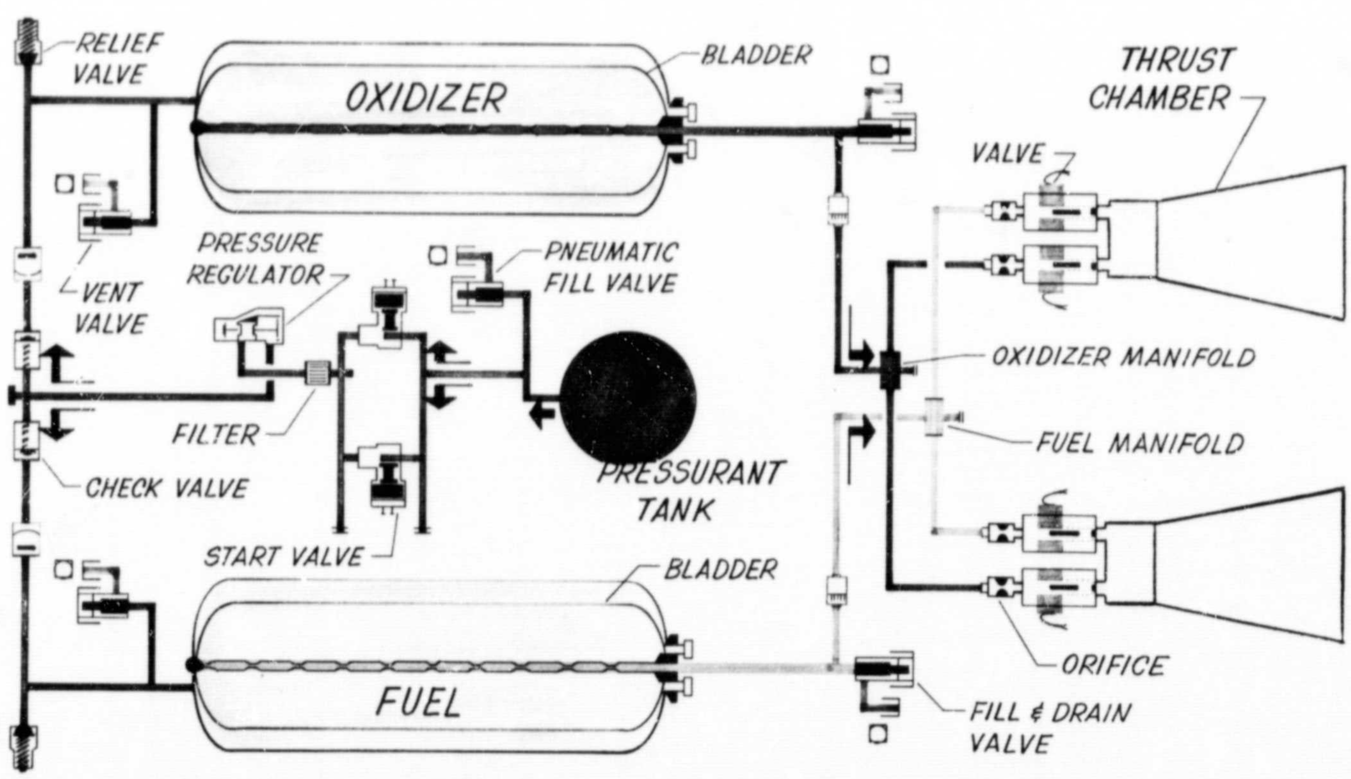


Fig. 2-7 Rocketdyne Secondary Propulsion System

2.2.3.2 Gemini Secondary Propulsion System.

LMSC Drawing Number: 1461865
Vendor: Bell Aerosystems Company

The SPS developed for the Gemini program is a completely contained module including positive expulsion propellant tanks, a gas pressurization system, one 16-pound thrust chamber assembly, and one 200-pound thrust chamber assembly. The system is shown schematically in Fig. 2-8, and the module is illustrated in Fig. 2-9. The modules can be mounted either in pairs or singly on the Agena aft rack. The system characteristics are listed below.

Characteristic	Value	
	Unit I	Unit II
Thrust (Vacuum)	16 lb	200 lb
Max. No. Cycles	90	20
Cycle Duration	0.5 to 150 sec	0.5 to 50 sec
Loaded Weight	303.8 lb	
Dry Weight	126.4 lb	
Total System Impulse	40,000 lb sec	
Operating Temp. Range	0° to $+100^{\circ}$F	
Fuel	UDMH	
Oxidizer	Mixed oxides of Nitrogen	

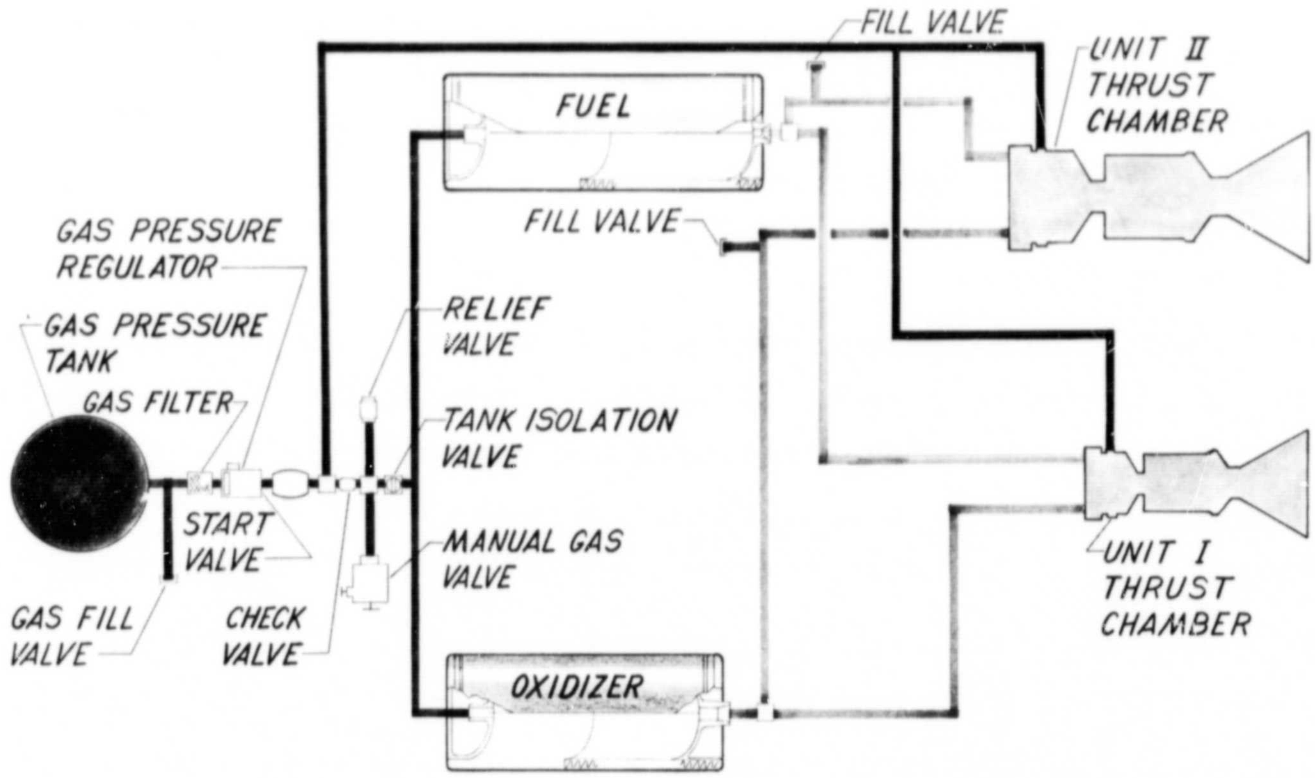


Fig. 2-8. Gemini Secondary Propulsion System

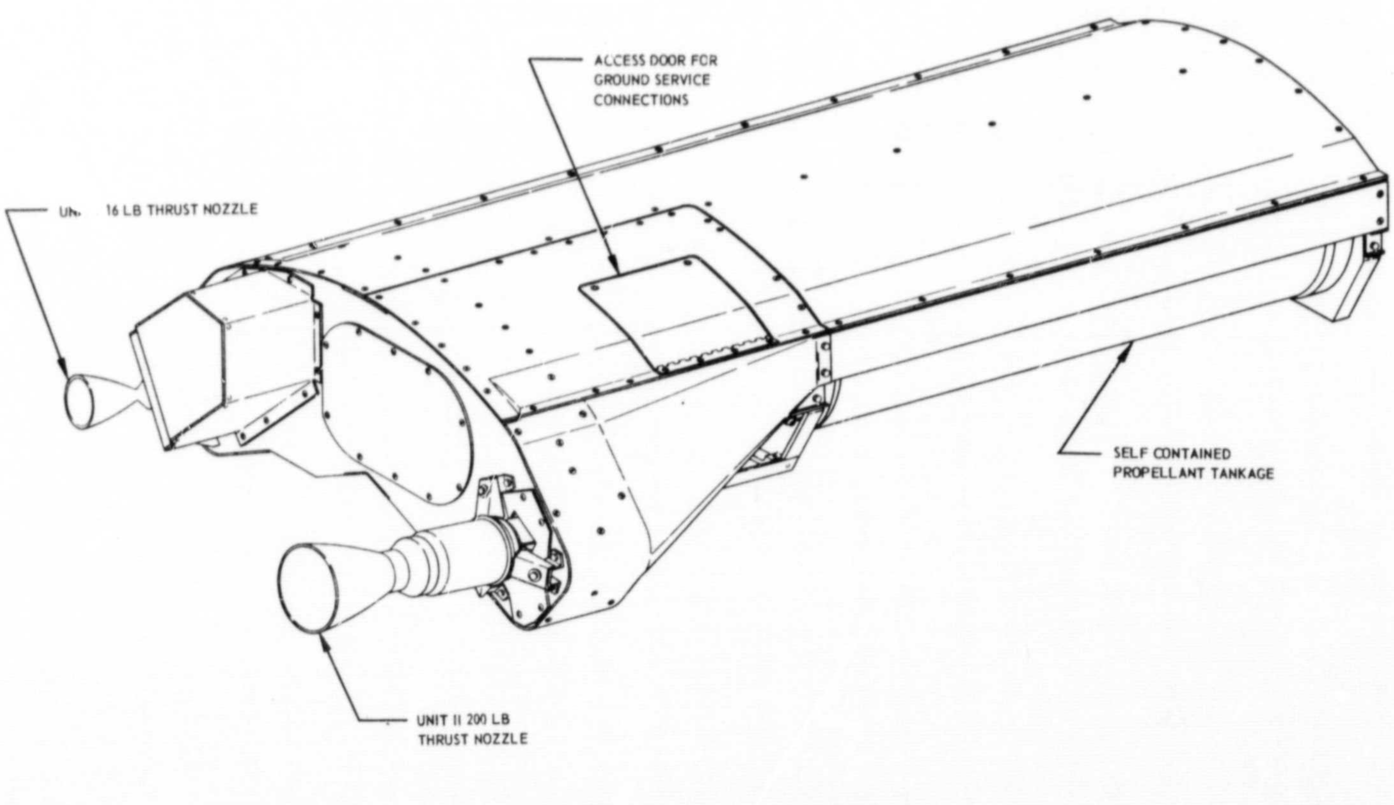


Fig. 2-9 Gemini SPS Module

2.2.3.3 Fixed Impulse Rockets. Several different fixed impulse rockets have been used for secondary propulsion purposes on Agena vehicles. The chracteristics of two rocket fixed-impulse types in current use on Agena programs are tabulated below. The first of the two types, manufactured by the Thiokol Chemical Corporation, is produced in two propellant load configurations and is used for drag makeup. The second of the two types, manufactured by Rocket Power Incorporated, is currently used on the Agena booster adapter for Thor and Atlas flights to provide retro-thrust during Agena/booster separation. The two types of rockets are shown in Figs. 2-10 and 2-11.

	Drag Makeup Rocket (Thiokol Chemical Corp.)		Agena/Booster Retro Rocket (Rocket Power Inc.)
	-501	-503	
Drawing No.	1462516	1462516	1462000
Spec. No.	1420165	1420165	1419115
Weight	13.6 lb	10.5 lb	4.69 lb
Thrust	427 lb	284 lb	490 lb
Total Impulse	3075 lb-sec	2050 lb-sec	455 lb-sec
Action Time	7.2 sec	7.2 sec	0.925 sec

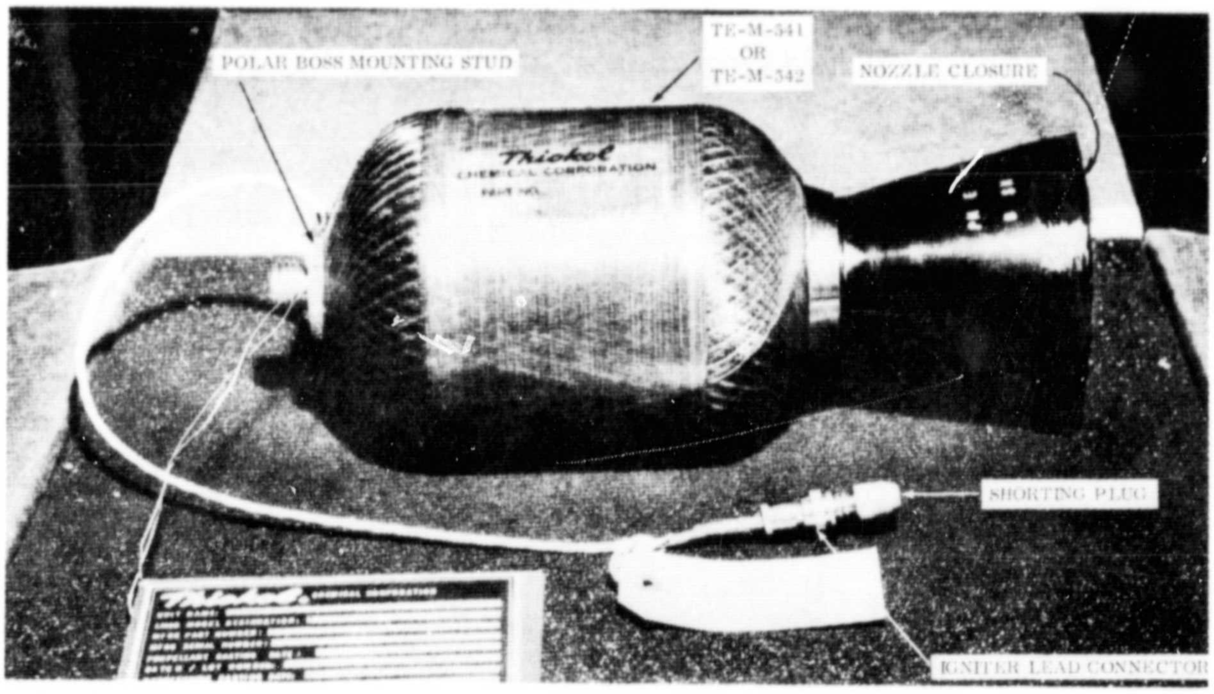


Fig. 2-10. Drag Makeup Rocket Motor

Fig. 2-11 Agena/Booster Separation Retro Rocket

2.2.4 Miscellaneous Pyro-Operated Devices

A wide variety of flight-proven, pyro-operated devices are available for mission-peculiar use. These devices can be employed for such functions as electrical disconnect, gas flow control, payload and secondary payload separation, and antenna erection. A representative few of the large number of qualified devices are described in the following paragraphs.

2.2.4.1 Rotary Electrical Disconnect.

LMSC Drawing Number: 1392024
LMSC Specification Number: None
Vendor: Built in-house by LMSC

This disconnect (Fig. 2-12) is a compact, lightweight unit used to provide remote separation of a 22-shell-size connector. The connector used contains 55 pins, but the unit can be adapted to any number of contacts within the Bendix 22-shell-size series of connectors.

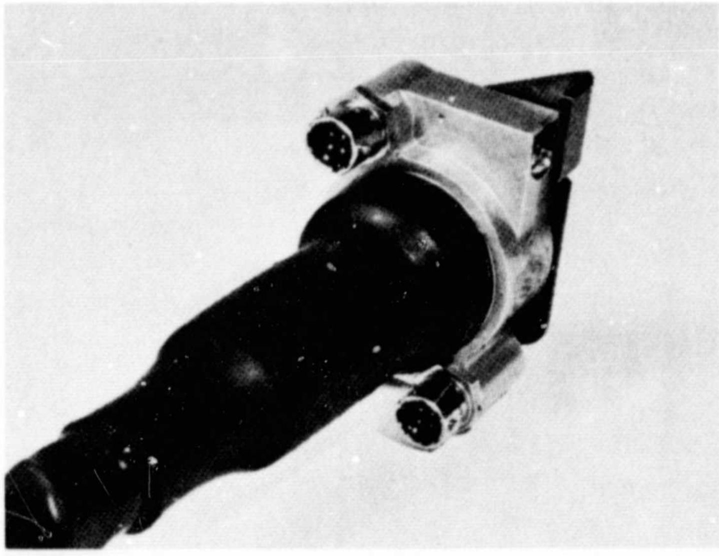


Fig. 2-12 Rotary Electrical Disconnect

2.2.4.2 Captive Separation Nut.

LMSC Drawing Number: 1462275

LMSC Specification Number: 1419938

Vendor: Hi-Shear Corporation

This separation nut (Fig. 2-13) is a squib-actuated device approximately 1-1/8 by 1-3/4 by 2-1/8 inches long. The unit mates with a 1/4-28 UNF-3B bolt and is non-bolt ejecting, which means that it imparts zero velocity to the bolt when it functions.

Fig. 2-13 Captive Separation Nut

2.2.4.3 Squib-Operated Release Assembly.

LMSC Drawing Number: 1464792
LMSC Specification Number: 1417565
Vendor: Holex, Inc.

The release assembly is an aluminum body 1.5 inches long and 1.6 inches in diameter. A 5/16-24 threaded stud protrudes 1.75 inch from each end of the body. Overall length of the assembly, including studs, is 5.0 inches. The body contains two 7/16-20 threaded ports for installation of the P/N 1618714-1 Pressure Cartridges. Minimum ultimate tensile strength of the assembly is 7600 pounds. Normal operating load is 3800 pounds.

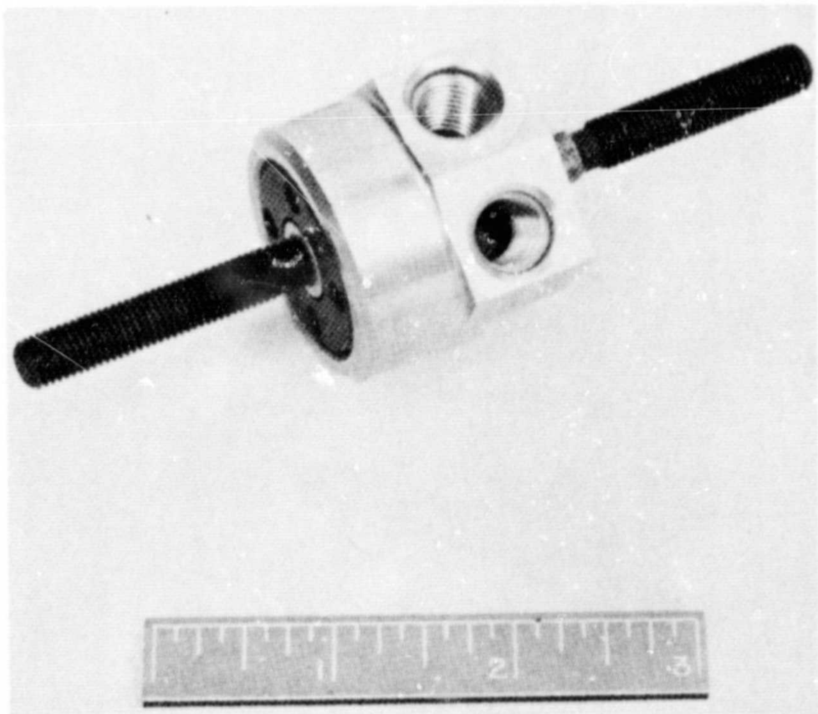


Fig. 2-14 Squib-Operated Release Assembly

2.2.4.4 Squib-Operated Pin Puller.

LMSC Drawing Number: 1372358
LMSC Specification Number: 1417827
Vendor: Built in-house by LMSC

This pin puller (Fig. 2-15) has an aluminum housing with overall dimensions 2.705 by 2.088 inches. The base of the housing has two mounting holes, and the side of the housing has provisions for two pressure squibs. A 1/4-inch-diameter pin extends approximately 1 inch from the base of the housing and the pin is retracted when the squibs are actuated.

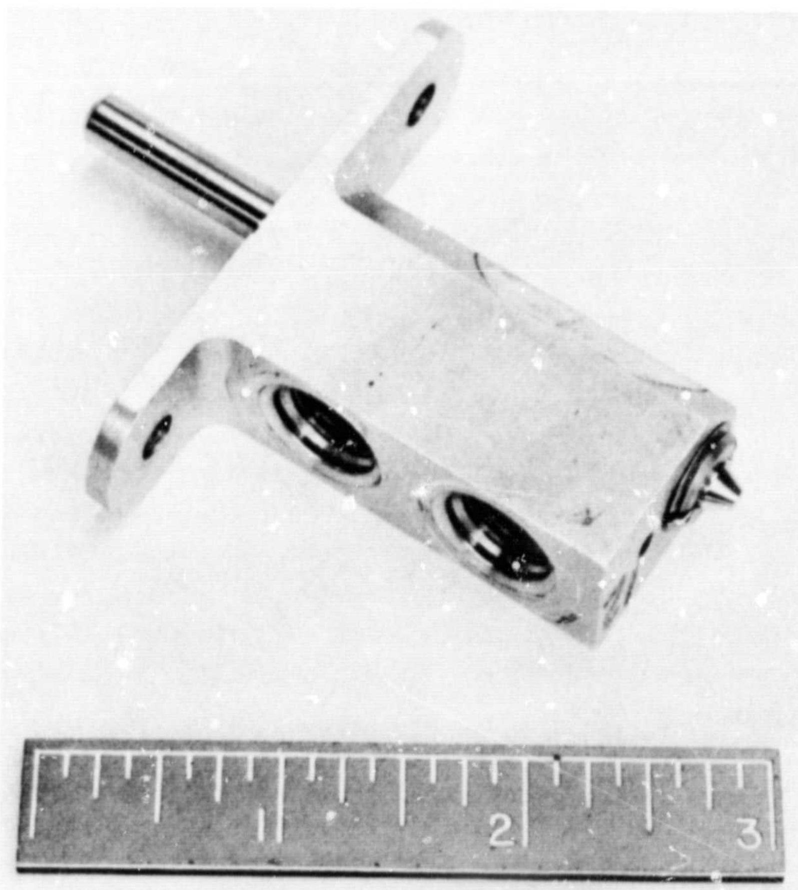


Fig. 2-15 Squib-Operated Pin Puller

Section 3
ELECTRICAL SYSTEM

PRECEDING PAGE BLANK NOT FILMED

Section 3
ELECTRICAL SYSTEM

3.1 BASIC VEHICLE ELECTRICAL SYSTEM

The electrical system for the basic Agena tug furnished electrical power and interconnects as diagrammed in Fig. 3-1. The system consists of silver-zinc primary batteries, a power distribution box, a telemetry junction box, a payload pyro and monitor box, an aft control and instrumentation box, and the necessary cables and wire harnesses. The selection of the batteries themselves depends on the mission requirements; the alternates available are presented in the section on mission peculiar electrical equipment

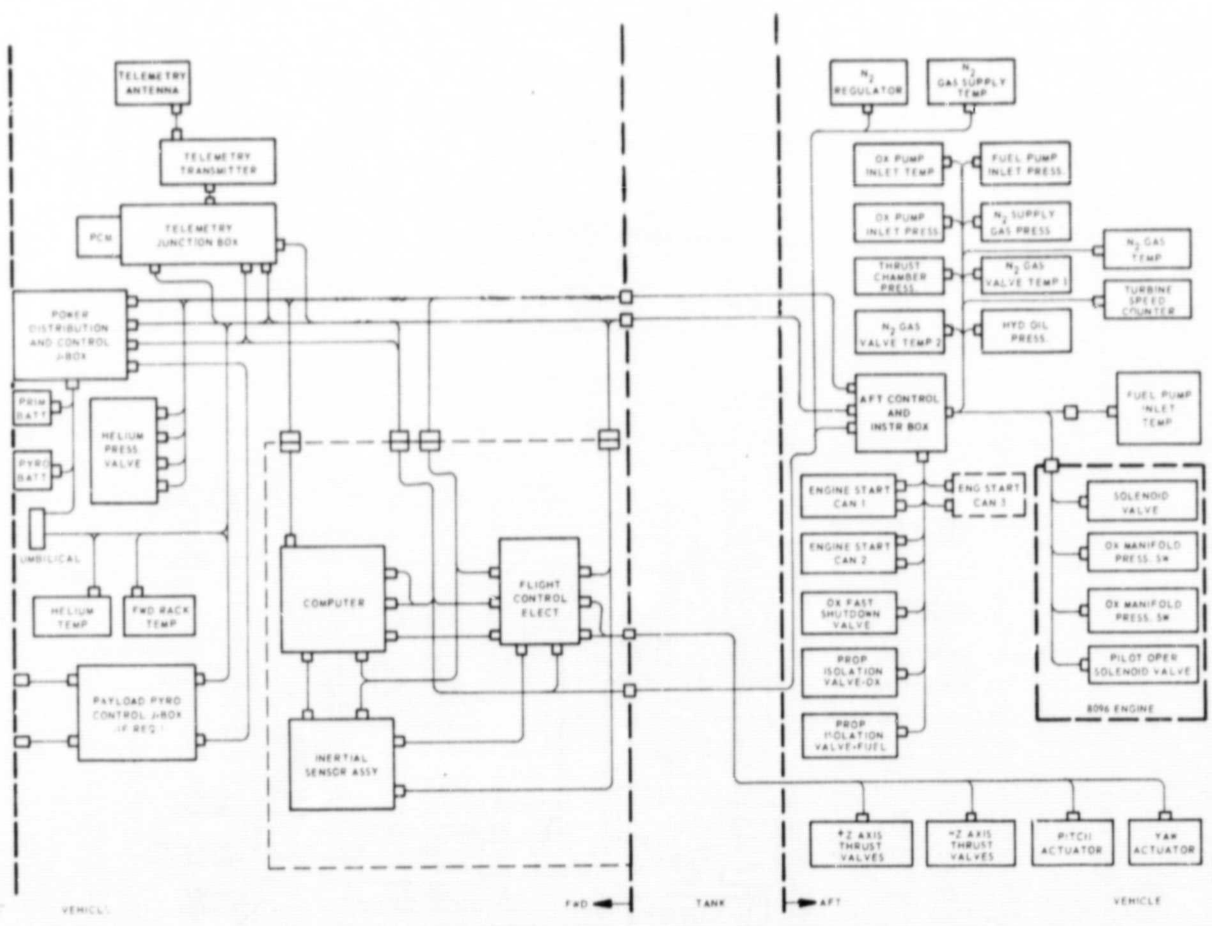


Fig. 3-1 Electrical Interconnect Diagram

3.1.1 Power Distribution and Control Box

LMSC Drawing Number: 1389613

LMSC Specification: 1420782

Vendor: Built in-house by LMSC

This unit (Fig. 3-2) consists essentially of bus bars, current sensors, and a power transfer switch for performing main power distribution, control, and monitoring functions, plus printed circuit modules for pyro control circuits and signal conditioning. The unit, weighing approximately 10 pounds, is located in the Agena forward section.

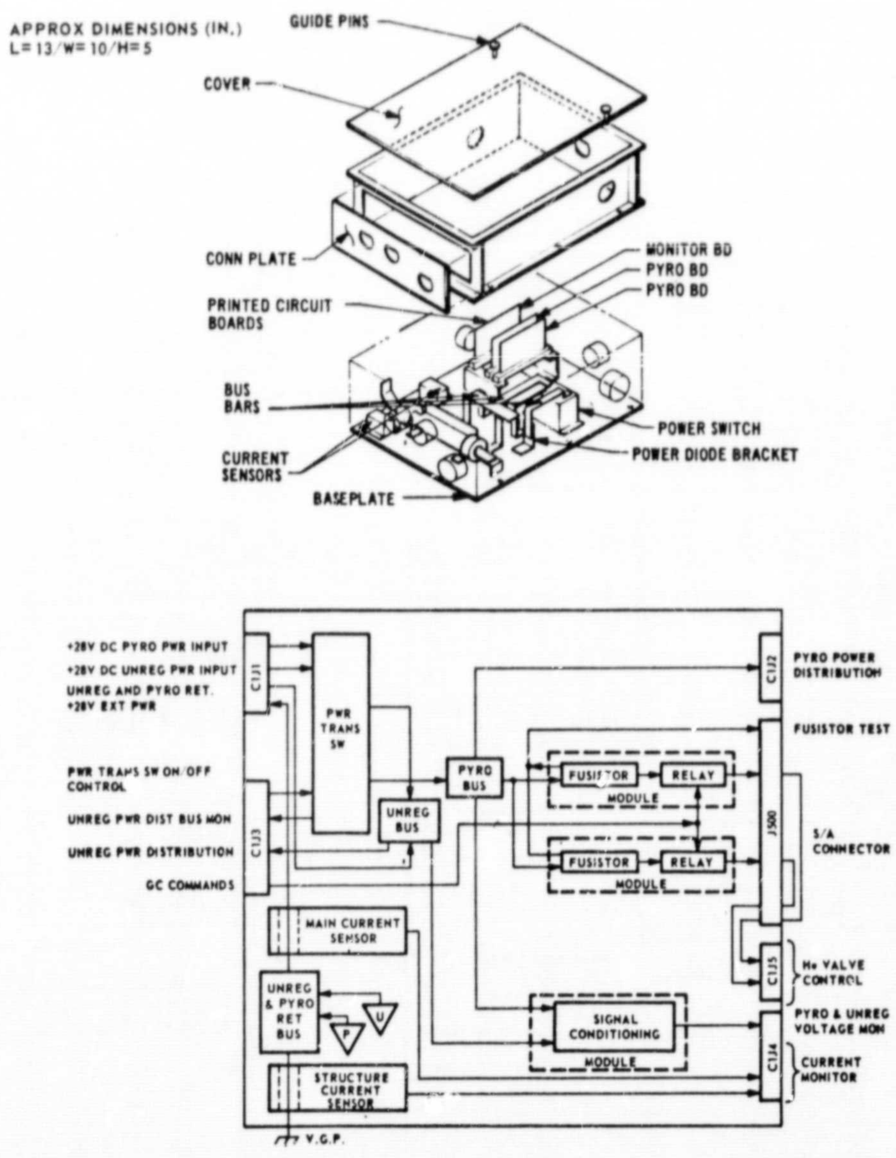


Fig. 3-2 Power Distribution and Control Box

3.1.2 Telemetry Junction Box

LMSC Drawing Number: 1389097

LMSC Specification: 1420799

Vendor: Built in-house by LMSC

This junction box (Fig. 3-3) is located in the Agena forward section, immediately adjacent to the Type 4 PCM telemeter unit; it weighs approximately 5 pounds.

Vehicle data monitor signals are received by this box and commutated through a terminal junction network to the PCM channel inputs. Unused channels are shorted to telemetry ground. The box also routes and controls power and AGE signals for controlling the UHF transmitter and PCM telemeter unit ON and OFF.

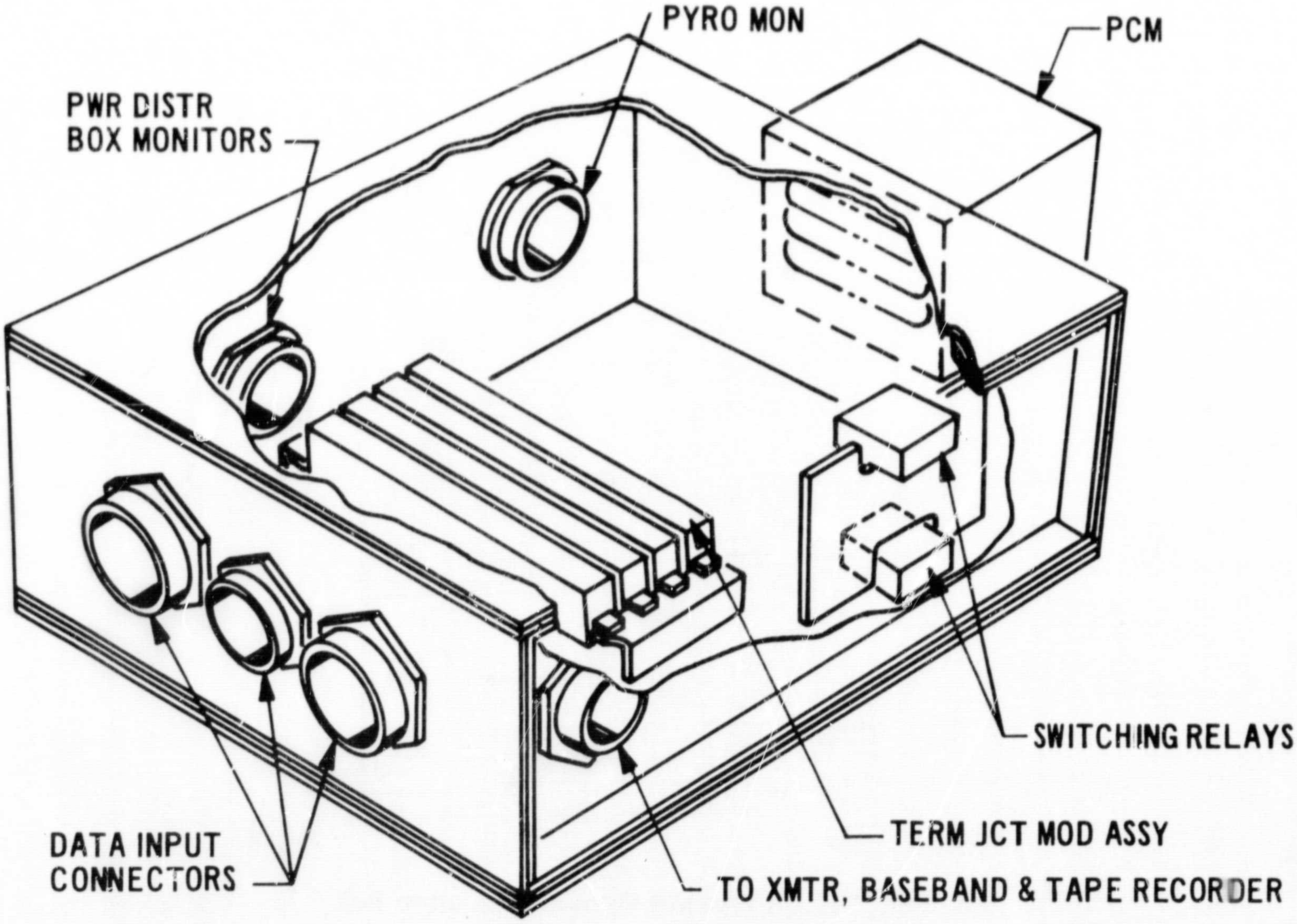


Fig. 3-3 Telemetry Junction Box

3.1.3 Program Pyro and Monitor Box

LMSC Drawing Number: 1389820

LMSC Specification Number: 1420800

Vendor: Built in-house by LMSC

This unit (Fig. 3-4) is also located in the Agena forward section. It consists essentially of five printed circuit assemblies mounted with a deep-drawn enclosure (Zero can) and weighs approximately 5 pounds.

The functions of this box are concerned with spacecraft separation and monitoring. Upon receipt of a command signal from the AGS guidance computer (GC), the box delivers current through fusistor-protected redundant circuits to the spacecraft separation bolts. The GC command, in parallel with the signal conditioning module (divider network), is sent to the PCM telemeter. A similar signal conditioning circuit is provided for spacecraft separation monitoring.

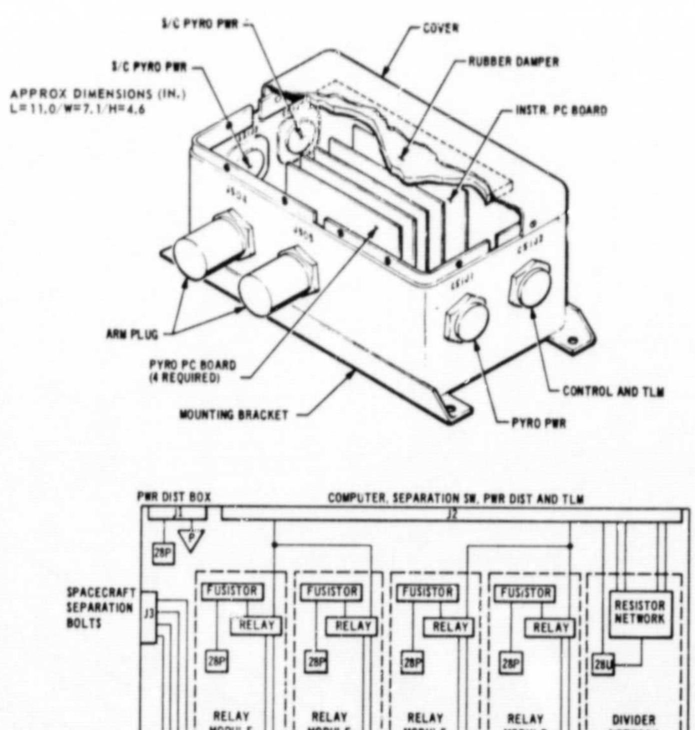


Fig. 3-4 Program Pyro and Monitor Box

3.1.4 Aft Control and Instrumentation Box

LMSC Drawing Number: 1389660
LMSC Specification Number: 1420801
Vendor: Built in-house by LMSC

This unit (Fig. 3-5) is mounted in the Agena aft section and provides the electrical interface for controlling and monitoring the propulsion system components and other equipment located on the aft rack. The unit weighs approximately 6 pounds.

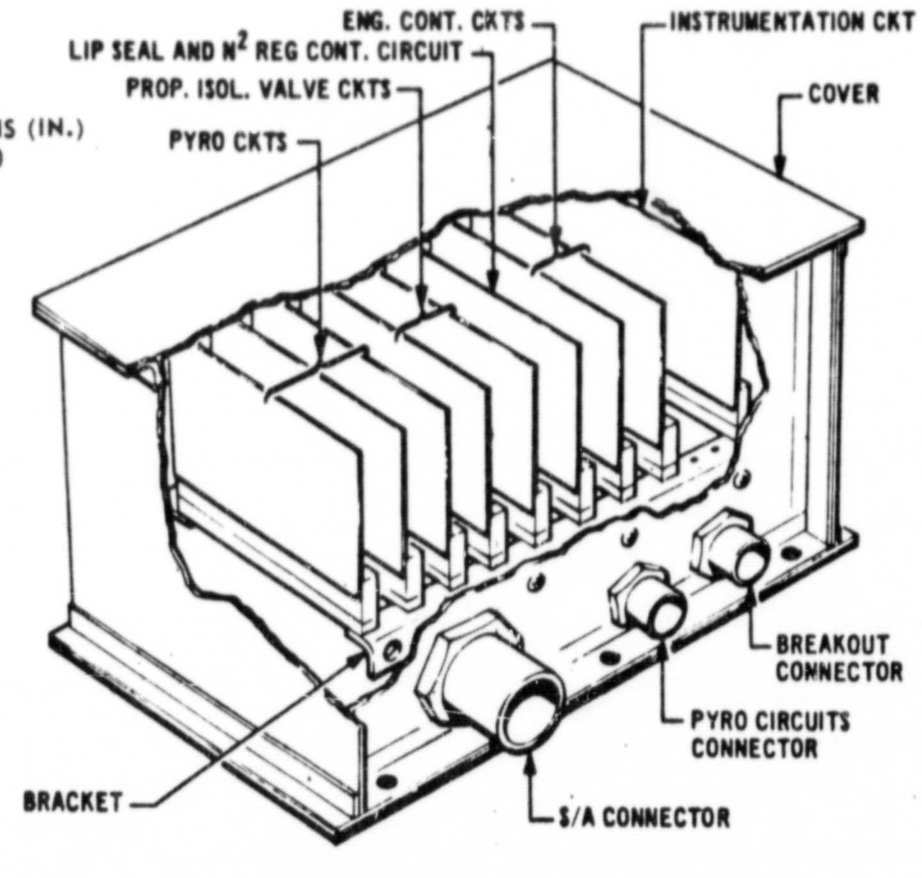
The oxidizer fast shutdown circuit and the engine start-can circuits are controlled by pyro circuits using 5-ampere nonlatching relays and fusistors. Operation of the pyro circuits is initiated by a GC command. The start-can circuits are redundant.

The engine arm circuit (included in the engine control circuitry) consists of three latching relays, each operating from a separate command signal. The circuit is designed to operate upon receipt of any two of the three commands. This principle of operation is also used for engine shutdown.

Blocking diodes in the oxidizer manifold pressure switch (OMPS) control circuits permit checkout of each of the two OMPS units during system test.

The propellant isolation valve (PIV) circuits and the lipseal/nitrogen regulator circuit each have four 5-ampere nonlatching relays connected in a series-parallel combination for redundant reliability. These circuits are controlled by GC command and use unregulated power.

The signal conditioning circuits accommodate the Agena aft section instrumentation requirements.



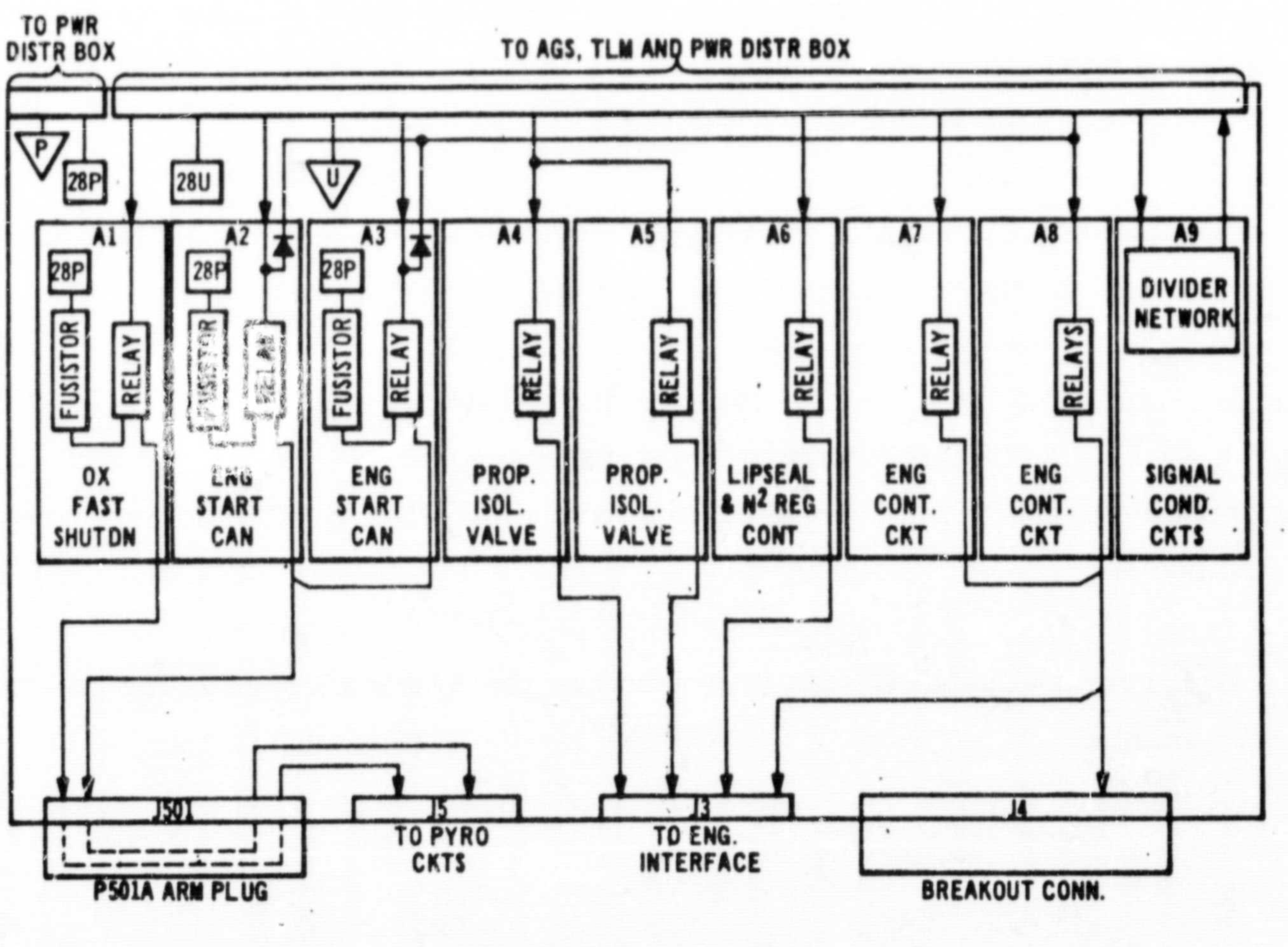


Fig. 3-5 Aft Control and Instrumentation Box

3.2 MISSION-PECULIAR ELECTRICAL EQUIPMENT

3.2.1 Primary Batteries

Table 3-1 lists the characteristics of an assortment of qualified, flight-proven primary batteries commonly used on Agena vehicles. These batteries can be used in various complements to meet a wide variety of mission requirements. All of the batteries shown in the table are manufactured by the Eagle Picher Company. Two of the primary batteries, the Type VIA and Type IC, are shown in Fig. 3-6 and 3-7.

Table 3-1
PRIMARY BATTERY CHARACTERISTICS

Type	Dwg No.	Cells	Nom Voltage	Amp-Hr	Wt (lb)
IC	1461791	16	24.5	450	118
IK	1462161	16	24.5	500	128
IVB	1462090	18	27.5	16	17
VI	1062762	17	26.0	70	26
VIA	1461198	17	26.0	45	26
24	1462049	16	24.5	45	21
30	8100133	18	27.5	400	134
31	8100019	18	27.5	13	16.5
1901	1462570	16	24.5	575	156

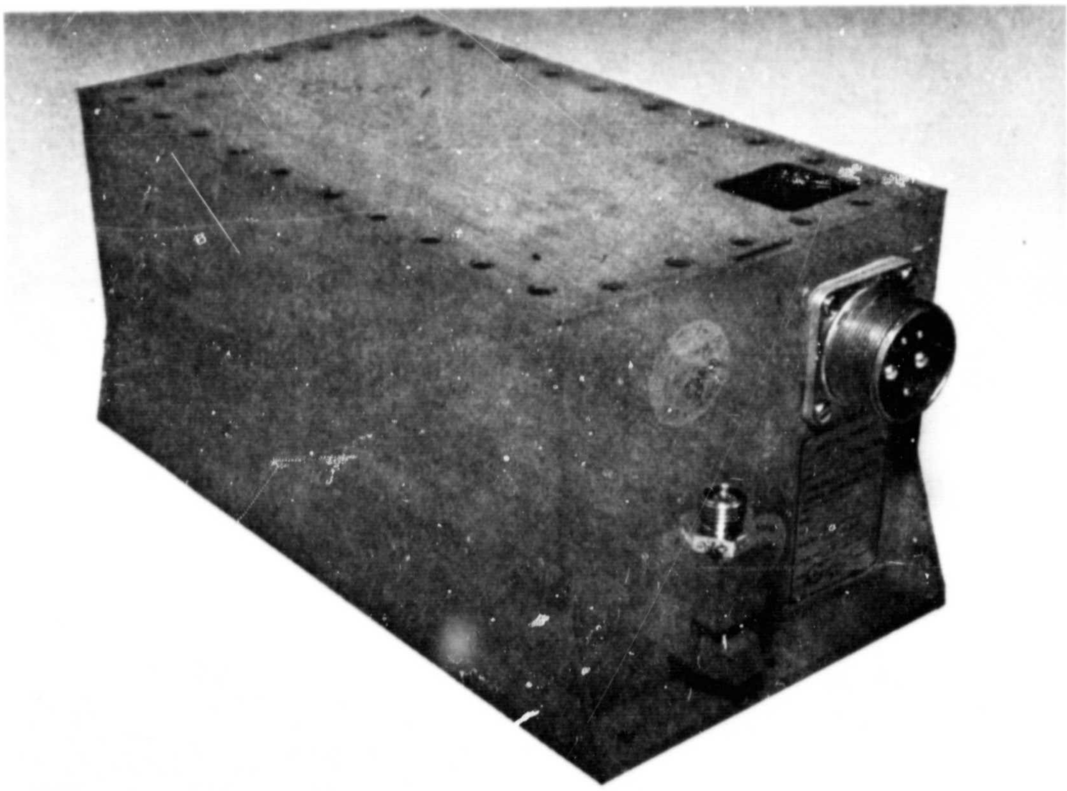


Fig. 3-6 Type VIA Primary Battery

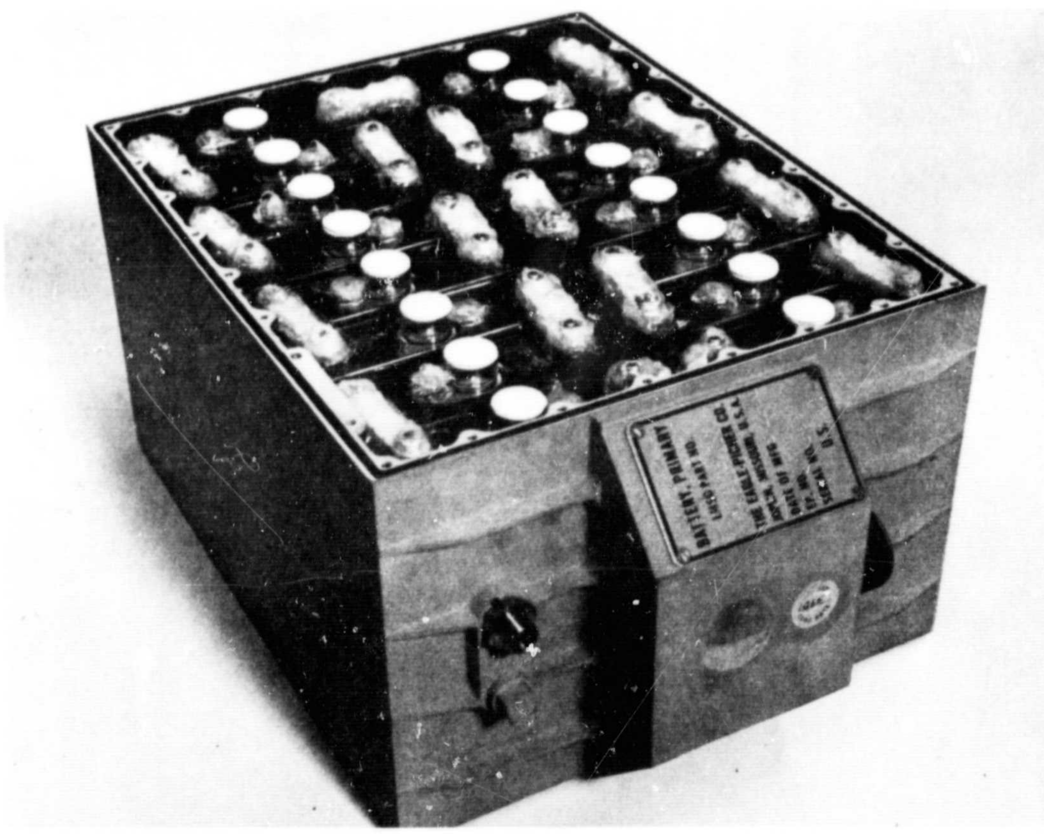


Fig. 3-7 Type IC Primary Battery with Cover Removed

3.2.2 Solar Arrays

Solar arrays can be used as the primary source of electrical power for missions requiring a longer life than is practical with only primary battery power. Several different configurations of foldout, rigid-substrate solar arrays are available and have been flown on a large number of Agnea vehicles. LMSC has also developed a lightweight flexible-substrate solar array design which offers a significantly higher power-to-weight ratio than is possible using the traditional rigid-substrate design.

The type of solar array system that has been flown extensively on Agena vehicles consists of one or more foldout solar array modules, rechargeable batteries, and a charge control assembly for each battery. In addition, some configurations employ a control system for sun-tracking purposes. The size and number of arrays, the type and number of batteries, and the configuration of the charge controllers depend on the total vehicle power requirements, the mission orbit, and the length of the mission life. Figure 3-8 shows an artist's concept of an Agena vehicle on orbit with a typical solar array configuration. The components used in this type of solar array system are described in the following pages.

Lightweight flexible solar arrays have been under development at LMSC since 1966. Currently, LMSC is furthering this experience under a NASA/MSC predevelopment contract for a space station solar array. The baseline design for this array utilizes a Kapton film for the substrate with the interconnect circuit incorporated as part of the substrate using printed circuit techniques and 2 x 4 cm wrap-around solar cells. Development is continuing with the goal of further optimizing interconnect materials, solderless joining techniques, solar cell cover materials and attachment techniques, and other variables.

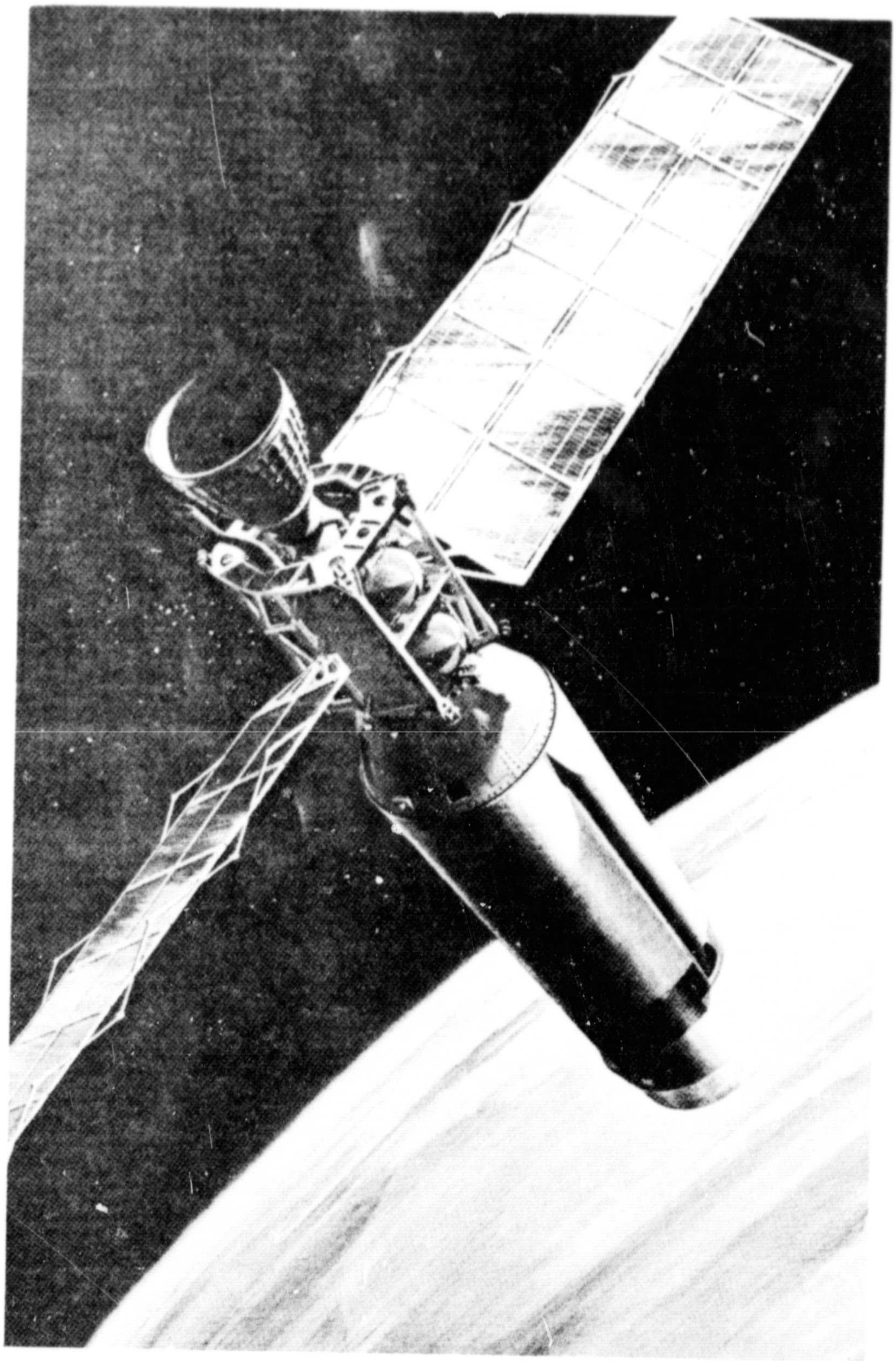


Fig. 3-8 Agena with Solar Arrays Extended

3.2.2.1 Rigid-Substrate Foldout Solar Array Modules.

LMSC Drawing and Specification Numbers:

Program	Drawing	Specification
A	1385286	1419662
B	1388725	1420794
C	1387736	1421443

Vendor: Built in-house by LMSC

These solar array modules are designed to be stowed on the Agena rack as shown in Fig. 3-9. The modules each contain a foldout solar array wing with from eight to ten hinged solar array leaf assemblies, each approximately 16.25 inches by 45.64 inches in size.

The leaf assemblies (LMSC Drawing 1462054, LMSC Specification 1419632) are manufactured by Electro Optical Systems Inc., and each assembly contains 960 solar cells mounted on a honeycomb panel. Each leaf assembly can produce up to about 45 watts when the sunlight is shining perpendicularly on the active side of the panel.

The solar array wing is deployed when two pin pullers controlling the wing assembly hold-down clamps are actuated in sequence. The force for deployment is provided by a spring-powered, hydraulically damped actuator.

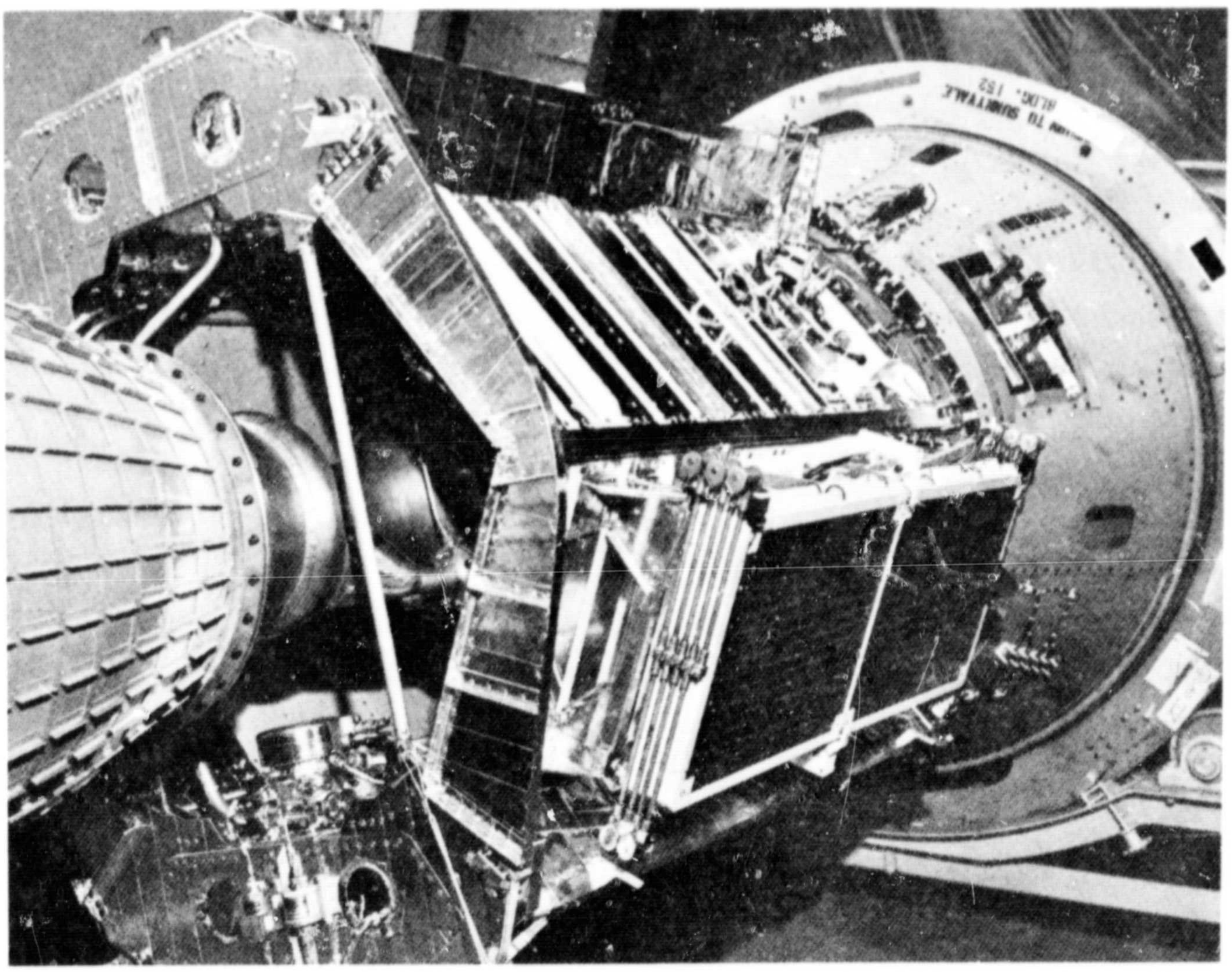


Fig. 3-9 Solar Array Module Mounted on Agena Aft Rack

3.2.2.2 Rechargeable Batteries. Several different rechargeable batteries are qualified and flight proven for use with solar arrays on Agena vehicles. The characteristics of three such batteries in current use are shown in Table 3-2. These batteries are also manufactured by the Eagle Picher Company.

Table 3-2
RECHARGEABLE BATTERY CHARACTERISTICS

Type	VII	XXV	29
Drawing	1461649	1462065	8100021
Specification	1412941	1419559	8100022
Type of Cells	Ni Cd	Ag Zn	Ni Cd
No. of Cells	20	16	22
Nominal Volts	25	25	27.5
Amp-Hours	36	300	45
Weight (lb)	72	116	105

3.2.2.3 Charge Controllers.

LMSC Drawing Number: 1387672
LMSC Specification Number: 1420984
Vendor: Built in-house by LMSC

Charge controllers are used in power systems utilizing solar arrays to control the charge rate of each battery as a function of battery voltage and temperature. Typically, a charge controller can supply either zero, 50, or 100 percent of the available charge to the battery.

The actual charge controller requirements for a particular mission depend upon the type of the solar array used and the type of battery used. The unit specified here is one of many different charge controllers which have been used on Agena vehicles and represents a qualified design that can be modified to satisfy a wide range of mission requirements.

3.2.3 Miscellaneous Power Equipment

Modern flight equipment is normally designed to operate from unregulated 28-volt power sources. However, several different inverters and converters are qualified for use on Agena vehicles; these units can be made available to meet particular mission requirements. One example of a mission peculiar requirement for an inverter would be to supply control moment gyros with three-phase, 400 Hz, 115-volt power. A common use for a converter is to supply transducers with excitation current. Table 3-3 shows the characteristics of several types of available inverters and converters.

Table 3-3
INVERTER AND CONVERTER CHARACTERISTICS

Nomenclature	Type	Drawing	Specification	Output			Input	Wt (lbs)
				Volts	Watts	V-A	(vdc)	
3 ϕ, 400 Hz Inverter	XIIB	1462172	1419881	115 ± 1%	-	0-200	22-29.3	18.25
3 ϕ, 400 Hz Inverter	XV	1464826	1420051	115 ± 2.5%	-	0-60	22-29.3	11.5
DC-DC Power Supply	IXB	1462173	1419880	±28.3 ± 1%	60/20	-	22-29.3	6.5
DC-DC Power Supply	X	1461411	1412481	±28.3 ± 1%	350/15	-	22-29.3	9.5
Transducer Power Supply	7	1462281	1420054	10.00 ± .05	.3/.3/.3	-	22-30	.31
DC-DC Converter (-5)	-	8100524	8100525	28 ± .25	9.8	-	22-30	0.7
DC-DC Converter (-7)	-	8100524	8100525	6 ± .09	9.0	-	22-30	0.7

Section 4

GUIDANCE AND FLIGHT CONTROLS SYSTEM

Section 4
GUIDANCE AND FLIGHT CONTROLS SYSTEM

4.1 BASIC VEHICLE GUIDANCE AND FLIGHT CONTROLS SYSTEM

The guidance and flight controls system for the basic Agena tug incorporates an onboard guidance computer and strapdown inertial reference system with a hydraulic thrust vector control system and a pneumatic attitude control system. The system provides the navigation, control, and command capabilities necessary to control steering and flight attitude and issue discretes during the performance of a programmed mission.

The guidance and flight controls equipment shown schematically in Fig. 4-1 consists of an inertial sensor assembly (ISA) and a guidance computer (GC), which make up the inertial guidance system (IGS), plus a flight control electronics (FCE) assembly and the necessary pneumatic and hydraulic control equipment.

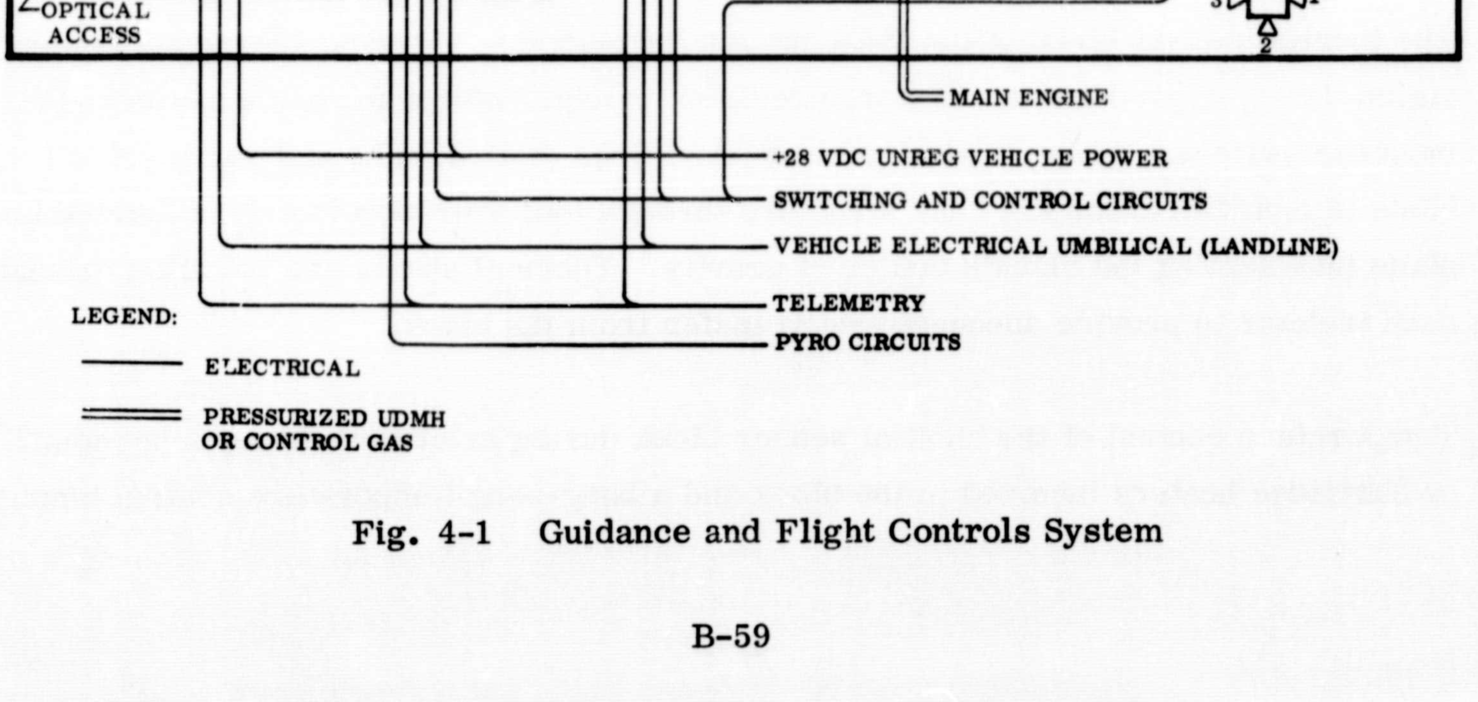


Fig. 4-1 Guidance and Flight Controls System

4.1.1 Inertial Sensor Assembly

LMSC Drawing Number: 1460976
LMSC Specification Number: 1420821
Vendor: Honeywell, Inc.

The inertial sensor assembly (ISA) senses rotation about the three vehicle axes and acceleration along these axes. The unit weighs 37.0 pounds and requires 137 watts of power during normal operation.

The ISA is shown in Fig. 4-2. Six mounting holes are provided for bolting the unit to the Agena forward rack. The thermally insulated protective cover has three windows for viewing an optical cube that is mounted on the sensor block to facilitate ISA alignment. A porro prism, also mounted on the sensor block for alignment purposes, is viewed through a window in the mounting base.

The ISA performs three-axis angular rate and linear acceleration measurements in a coordinate system related to the mounting base of the unit. The unit is capable of determining angular rates up to 25 degrees per second with quantization ranges of 6.2947 arc seconds per pulse (low range) or 50.3576 arc seconds per pulse (high range). Acceleration is measured in each of the three axes up to 15 g. The quantization of the incremental velocity information is 0.27 foot per second per pulse. The rebalance rate of both the gyro and accelerometer loops is 1800 pulses per second.

The inertial sensor block of the ISA contains three gyros, three accelerometers, precision timing crystal and oscillator, precision voltage reference, block heaters, thermostatic switches, and optical alignment provisions (optical cube and porro prism). The block is mounted to the ISA base structure through four vibration isolators located in a plane intersecting the block's center of gravity. Thermal shunts are installed around each isolator to provide adequate heat transfer from the block.

Temperature control of the inertial sensor block during orbit operations is accomplished by cartridge heaters inserted in the block and a bang-bang temperature control amplifier.

This thermal control method maintains the operating temperature of all three accelerometers at +167°F. Gyro operating temperatures are maintained at +184° F by an individual temperature control amplifier and internal heater for each gyro.

The angular rate sensing devices are Honeywell GG334A8 single-degree-of-freedom, integrating gyros. These gyros are of the floated type and utilize a hydrodynamic gas bearing spin motor. Gimbal travel is restricted to less than 1 degree. Significant design features of the gyro are shown in Fig. 4-3. Gyro drift rates and stabilities are considered critical performance parameters and the gyros are designed to meet the following requirements:

a. G-insensitive drift when shipped ±0.3 deg/hr (maximum), 120-day stability ±0.25 deg/hr (3-sigma)
b. G-sensitive drift when shipped ±2.0 deg/hr/g (maximum), 120-day stability ±0.6 deg/hr/g (3-sigma)

Vehicle accelerations are measured by Honeywell GG177P5 accelerometers. These instruments are the flexure pivot type with fluid damping and have been used successfully on a number of Honeywell programs. Accelerometer details are shown in Fig. 4-3. The null bias is less than 200×10^{-6} g when shipped and is stable within 100×10^{-6} g for a 120-day period. As with gyro drifts, this is considered a key performance characteristic.

The inertial sensor electronics subassembly contains a precision timing generator, precision voltage regulator, temperature control amplifiers (TCAs), and the gyro and accelerometer rebalance loop electronics. The function of the sensor rebalance loops is to provide accurately measured current pulses to the respective torquers to maintain gyro and accelerometer null positions.

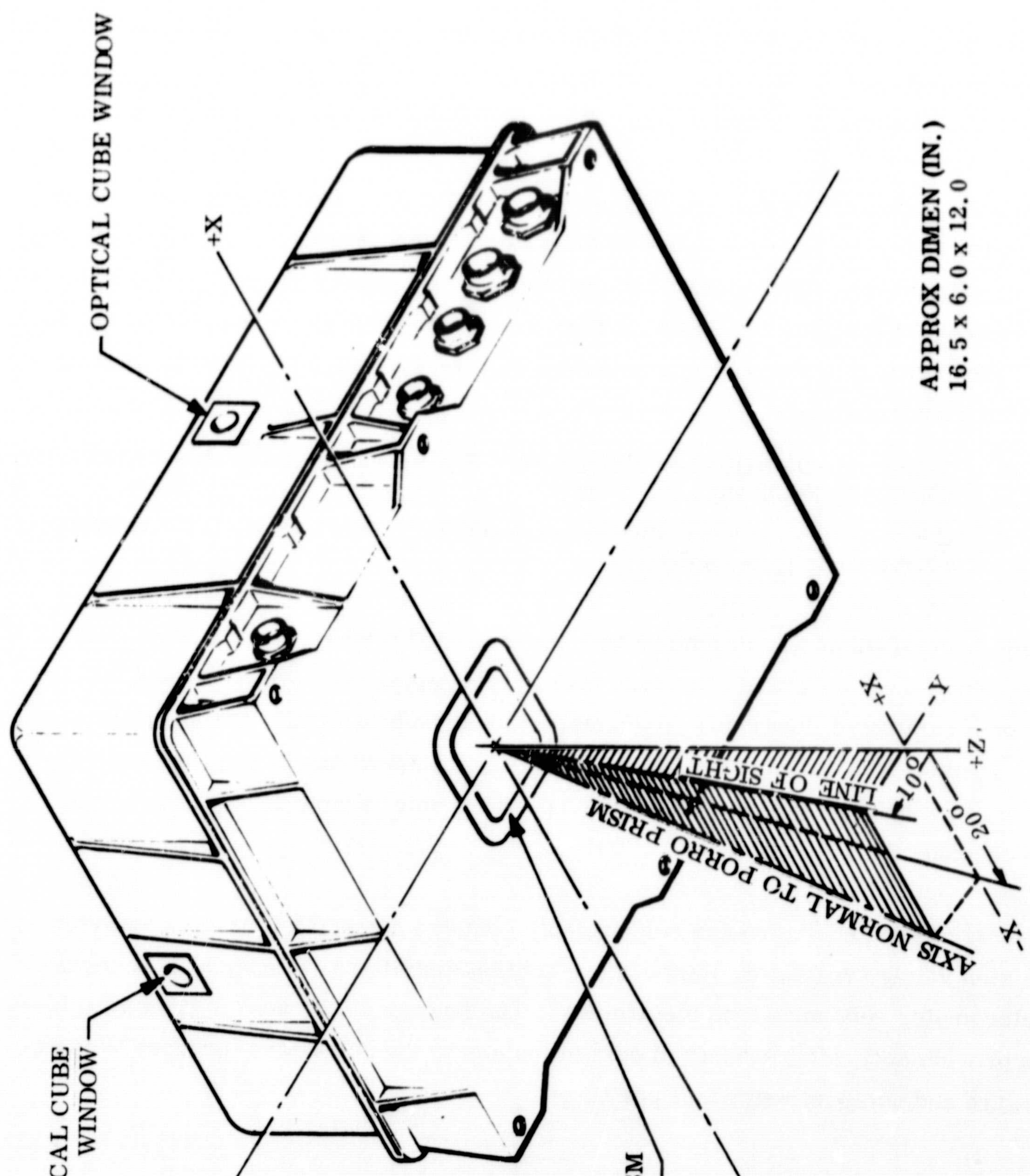
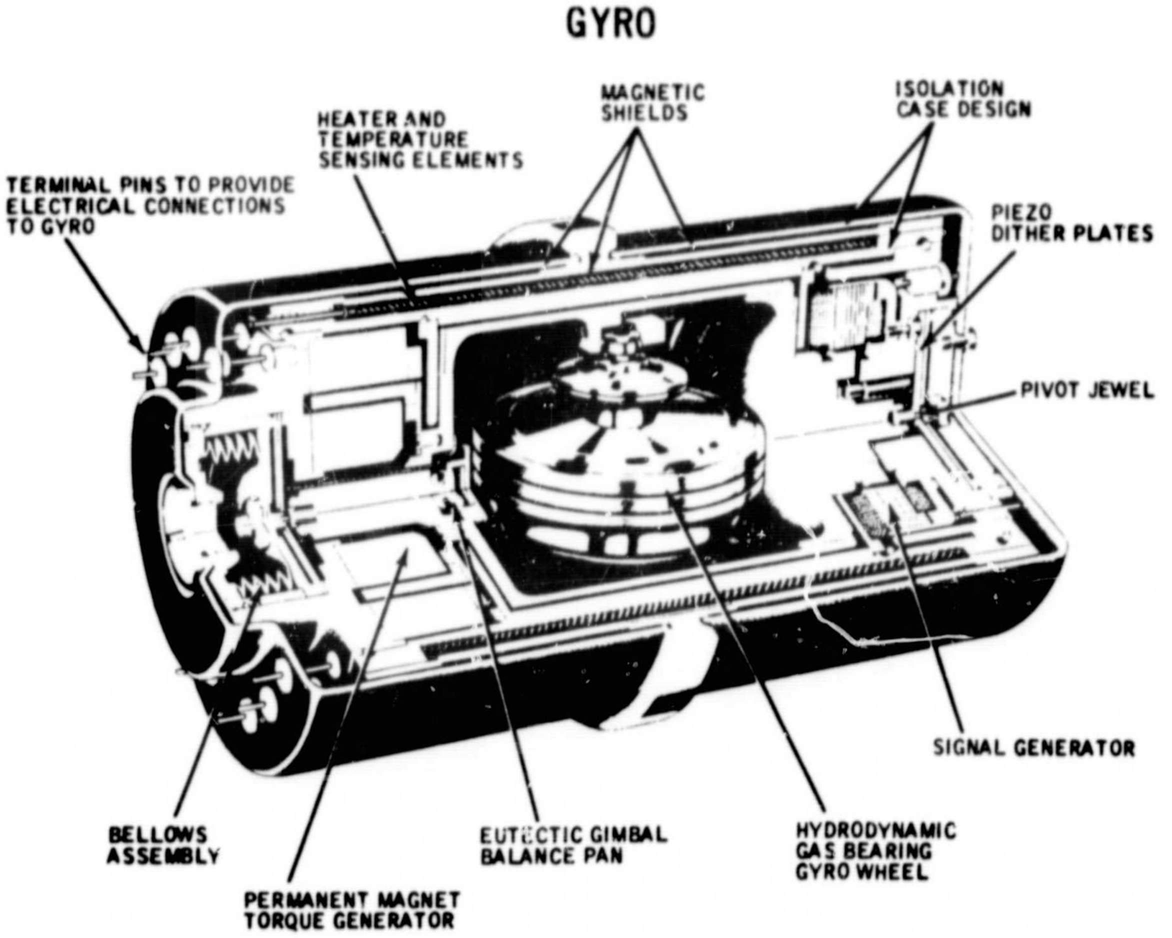


Fig. 4-2 Inertial Sensor Assembly



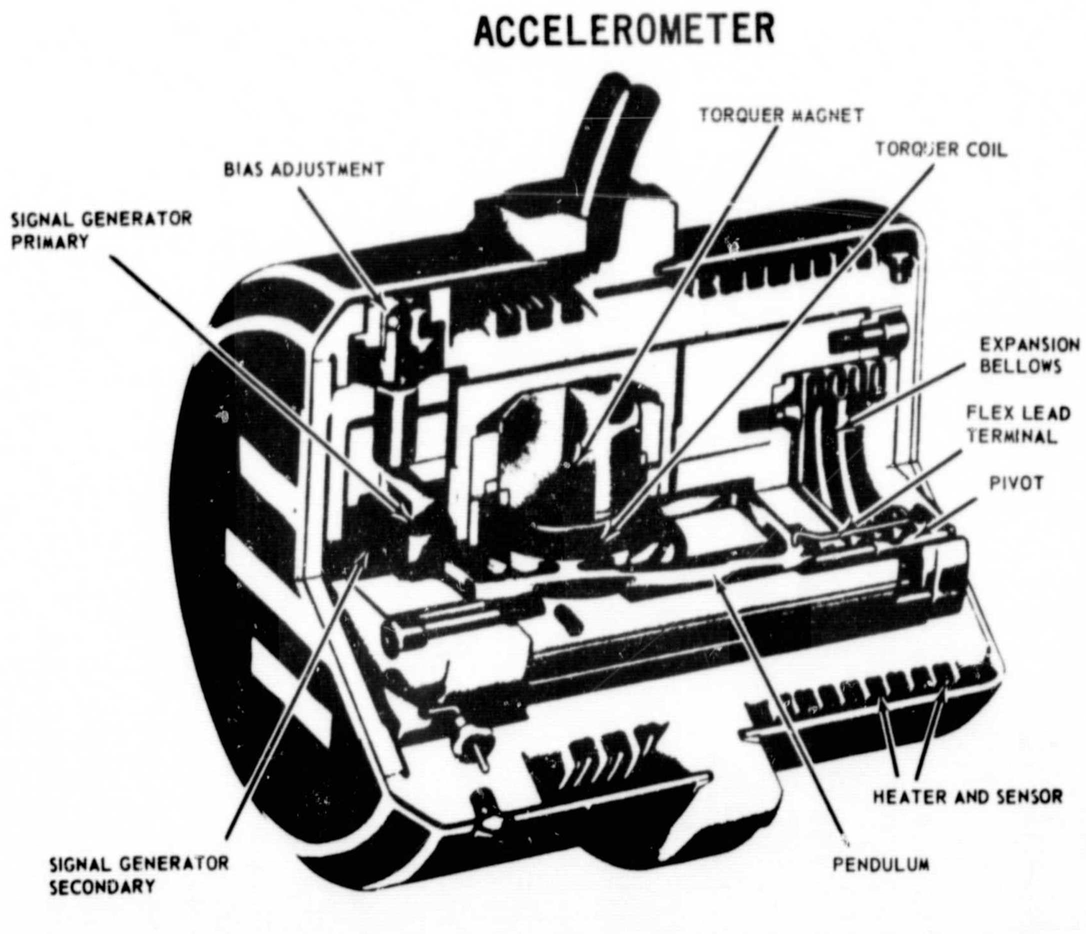


Fig. 4-3 Cutaway Views of Inertial Sensors

4.1.2 Guidance Computer

LMSC Drawing Number: 1460977
LMSC Specification Number: 1420821
Vendor: Honeywell, Inc.

The Agena guidance computer (GC) is a combination general purpose and special purpose binary digital computer consisting of a processor, a memory, an input/output section, and a power supply. The computer processes acceleration and angular rate data from the ISA, formats and outputs telemetry data, and issues steering signals and vehicle discretes as required to perform the required missions. The unit weighs 47.0 pounds; it requires an approximately 144 watts of power. Figure 4-4 shows the physical configuration of the GC.

The GC processor section controls the operations, furnishes the timing and logic signals, and contains the arithmetic and control registers for executing the stored program. A sequencer provided in the processor allows the pulse inputs from the ISA to be processed in a minimum of time.

The GC utilizes a parallel, modified random access, coincident-current magnetic core memory. The memory is configured in two banks with 4096 20-bit words per bank. An individual read-or-write operation requires one clock time, or 1.0 microsecond. The process of reading and then immediately restoring, which is generally referred to as memory cycle time, requires 2.0 microseconds.

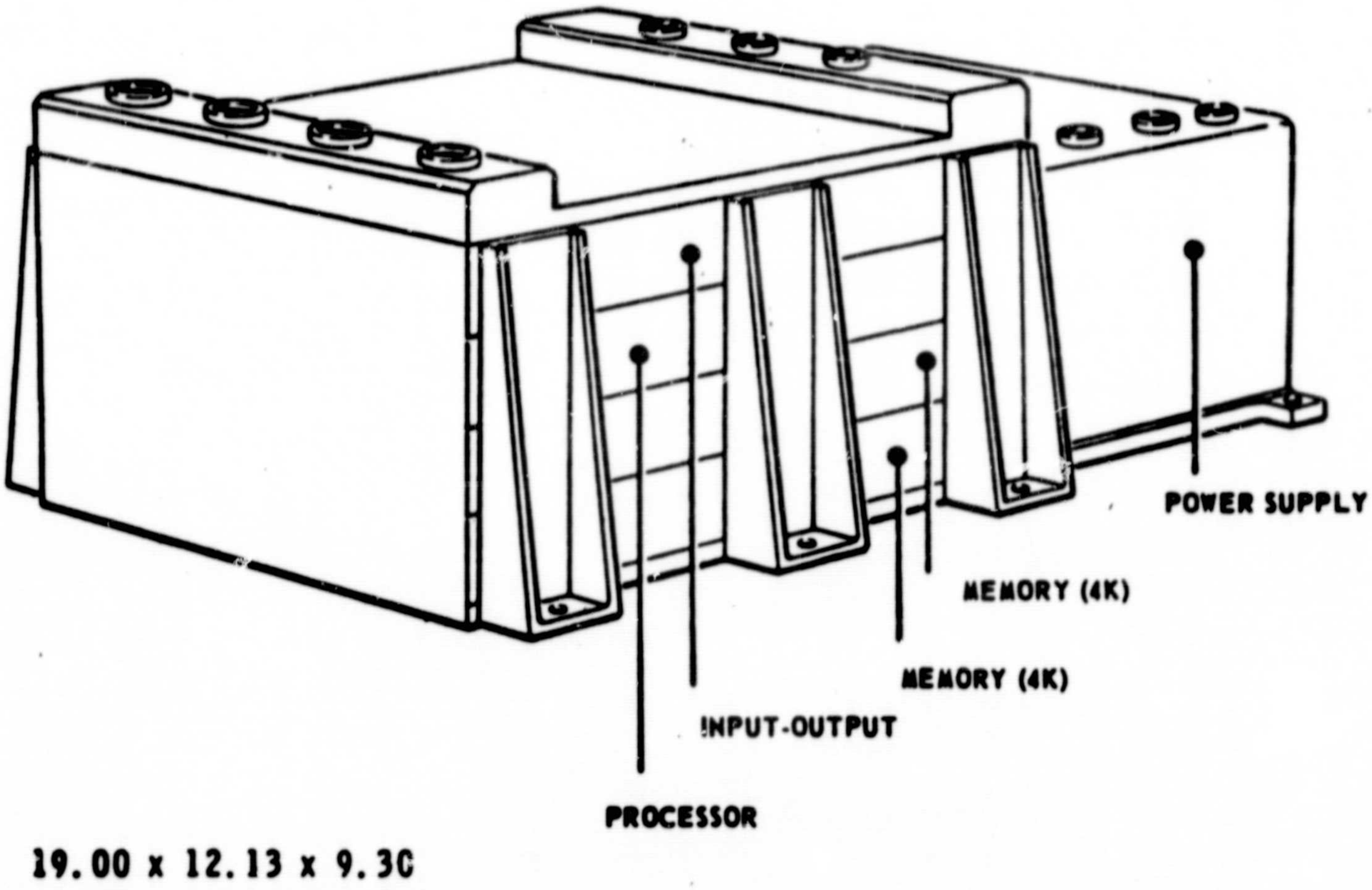


Fig. 4-4 Guidance Computer Assembly

The input/output (I/O) section contains the circuitry necessary to interface the external systems with the GC processor. A block diagram of I/O is shown in Fig. 4-5. The I/O performs the following functions:

a. Buffers and adjusts signal levels
b. Sends and receives serial data
c. Sends and receives parallel data
d. Priority-interrupts the processor
e. Receives discrete inputs
f. Sends level and pulse outputs
g. Performs address holding and decoding
h. Derives timing information

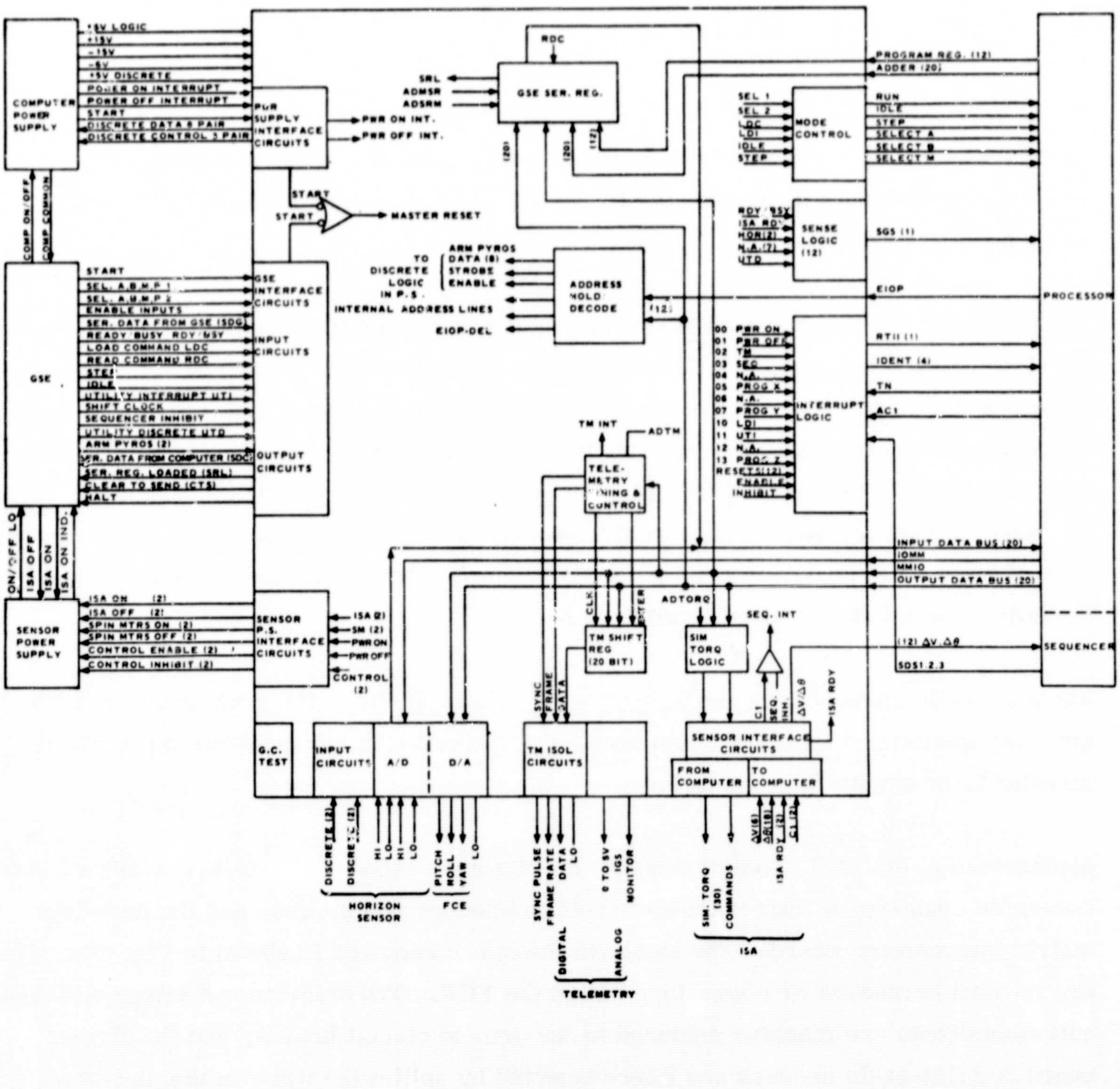


Fig. 4-5 Input/Output (I/O) Block Diagram

4.1.3 Flight Control Electronics

LMSC Drawing Number: 1389670
LMSC Specification Number: 1420797
Vendor: Built in-house by LMSC

The flight control electronics (FCE) provides an interface between the attitude control commands from the GC and the attitude control devices that these commands actuate. The FCE contains separate channels for thrust vector control hydraulics and for the pneumatic thrust valves.

The hydraulic channel consists of two identical servo amplifiers on a single card, one for pitch and one for yaw. The amplifiers are the differential input type with two unipolar outputs each. Each output goes to one of the two servomotor coils in the electrohydraulic servo actuator. Actuator position, indicated by the wiper of a wire-wound potentiometer, is fed back to the summing point of the servo amplifier. This closes the inner, or servo, loop of the thrust vector control system. The amplifier is powered from the +20 volt regulator board in the FCE which provides 0.25 percent regulation for amplifier operation and actuator excitation.

The pneumatic channel consists of six power gain stages (one for each thruster) with arc suppression and associated components. The valve driver input has a threshold detector to eliminate false triggering.

Mechanically, the FCE consists essentially of a spotwelded magnesium enclosure, three flat-cable connectors, four printed-circuit component assemblies, and the four-layer matrix interconnect board. The unit with the cover removed is shown in Fig. 4-6. There are no wire harnesses or connectors within the FCE. The discrete and integrated circuit components are machine soldered to the printed circuit boards, and the circuit board and flat-cable headers are interconnected by split-wire wrap on the phosphor-bronze traces of the matrix board.

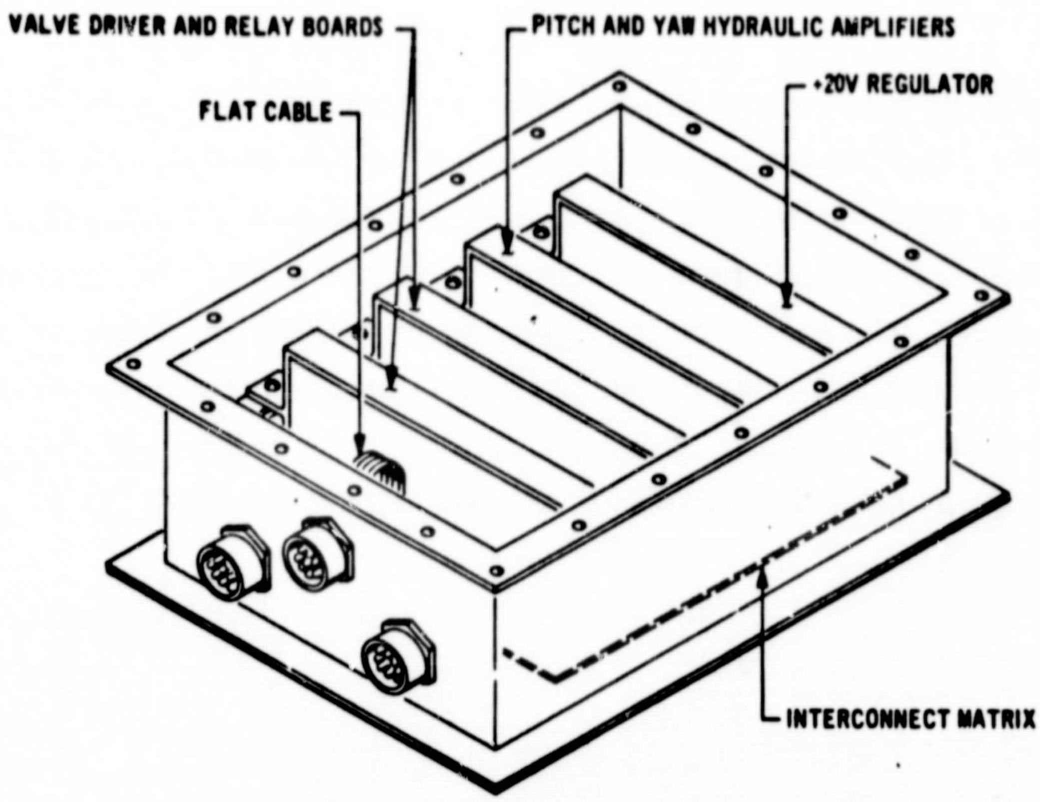


Fig. 4-6 Flight Control Electronics Assembly With Cover Removed

4.1.4 Pneumatic Attitude Control System

The pneumatic attitude control system (Fig. 4-7) consists of a pneumatic pressure regulator, two thrust-valve clusters, and a 2200-cubic-inch control gas storage sphere. The function of this system is to apply corrective torques about the three vehicle axes when commanded by the guidance computer. The pneumatic system provides pitch, roll, and yaw control, except during Agena engine burns, when the pneumatic system continues to provide roll control, but pitch and yaw control are transferred to the hydraulic system. Provisions are also included in the system for additional control gas storage spheres when required for extended life missions.

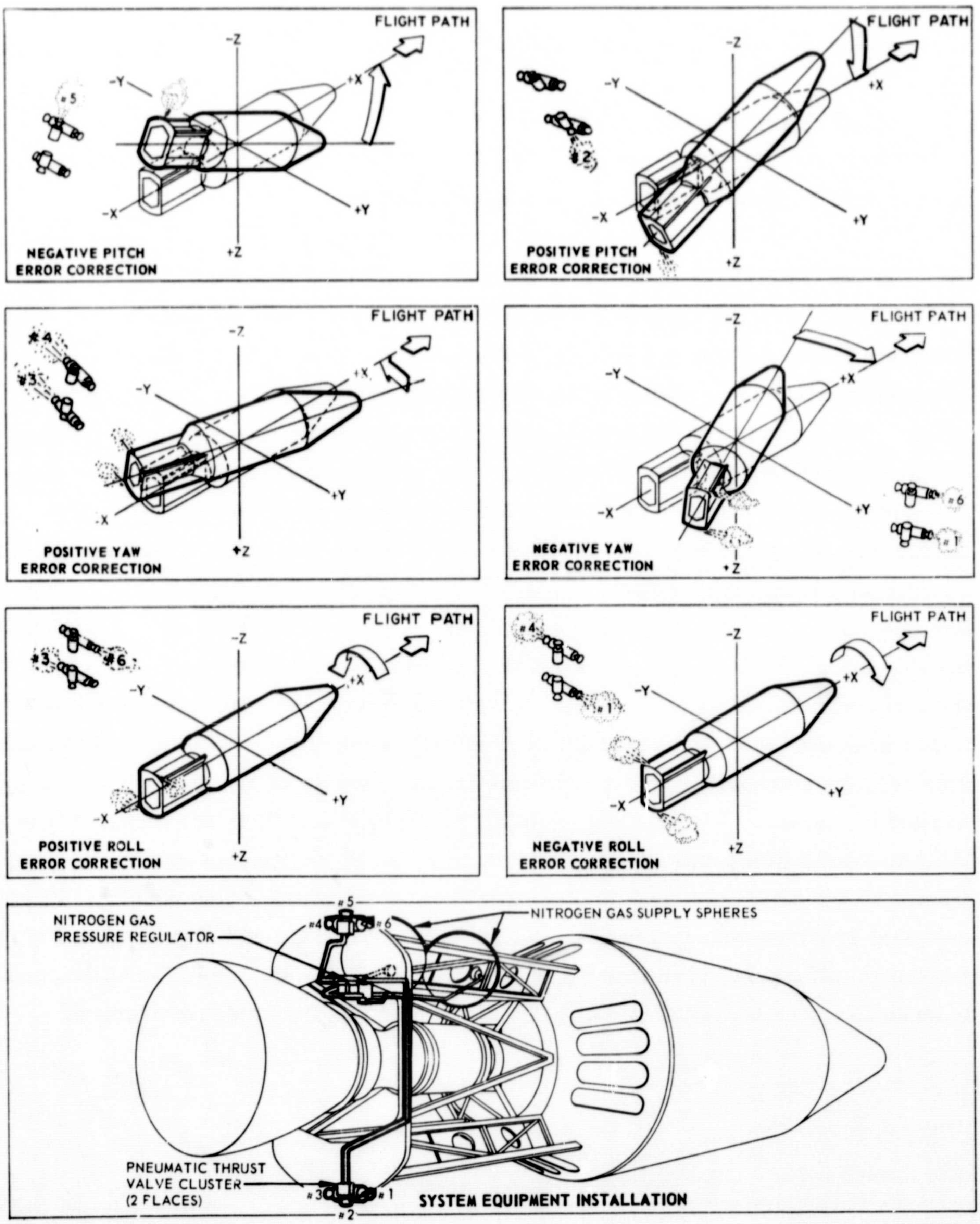


Fig. 4-7 Pneumatic Flight Control System

4.1.4.1 Pneumatic Pressure Regulator.

LMSC Drawing Number: 1461952
LMSC Specification Number: 1414273
Vendor: Sterer Engineering and Manufacturing

The pneumatic pressure regulator (Fig. 4-8) reduces the pressure of the gas fed to the thrust valves from the level in the supply sphere to a nominal 100 psig for high-mode operation and to a nominal 5 psig for low-mode operation. The regulator also provides essentially constant regulation to the selected pressure while the thrust valves are pulsing, thus drawing on the gas supply. The regulator adjusts the nominal 100-psia and 5-psia regulated pressures to higher values when the surrounding atmosphere pressure is above zero, so that the thrust produced by each valve is maintained at nearly the nominal 10 pounds (high mode) or 0.5 pound (low mode) despite the thrust-countering ambient atmosphere. An additional function of the regulator is to supply low-pressure nitrogen gas to the Agena engine to pressurize the lipseal in the oxidizer turbine pump. This seal is pressurized to prevent oxidizer leakage from seeping along the turbine shaft into the turbine gear case. The regulator outlet pressure is maintained at one of two selected values by constantly comparing it with one of two selectable reference pressures, which are maintained in a pair of cylindrical chambers located on one side of the regulator body. As the gas is used by the thrust valves and the regulated outlet pressure being fed to them begins to drop, an unbalanced condition occurs on the diaphragm assembly contained in the regulator dome housing. This unbalanced condition causes a check valve to open between the gas supply sphere and the regulator outlet port, restoring the pressure of the gas being fed to the valves and the balance of forces that existed within the housing before the pressure dropped.

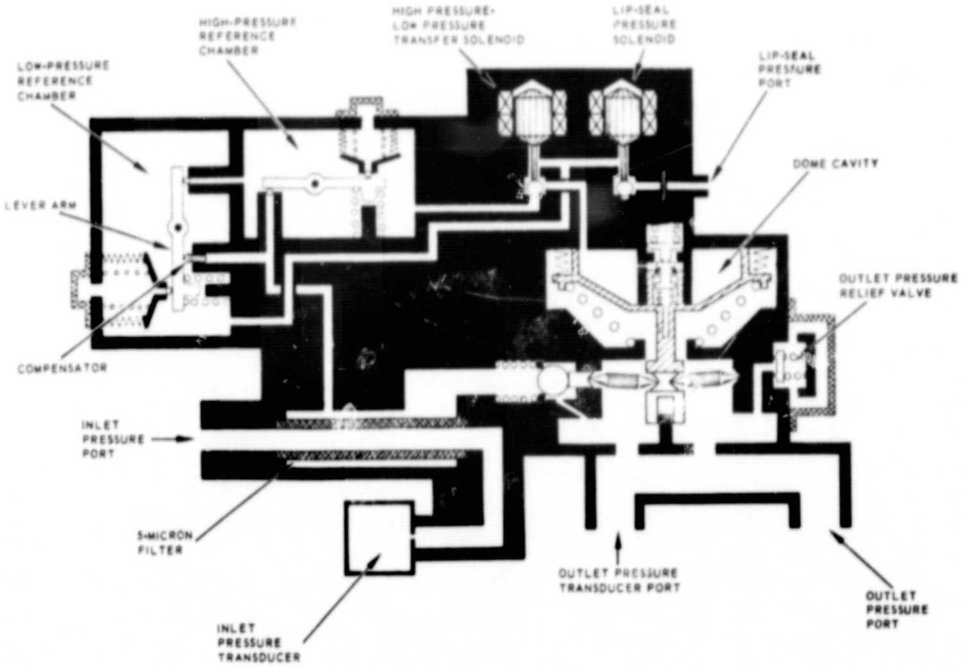


Fig. 4-8 Pneumatic Pressure Regulator

4.1.4.2 Thrust Valve Cluster.

LMSC Drawing Number: 1462553

LMSC Specification Number: 1420741

Vendor: Supplied both by Sterer Engineering and Manufacturing and by Weston Hydraulics Limited

The solenoid-operated thrust-valve cluster (Fig. 4-9) consists of three identical thrust valve cartridges mounted on a single manifold containing a pressure port and electrical receptacle common to the three valves. The thrust valves receive compressed gas from the nitrogen pressure regulator. Each valve operates independently. Energizing the solenoid of a valve opens the valve, and the resulting gas flow produces thrust. This is accomplished in the following manner. When the solenoid is actuated, the plunger is pulled back, moving the flange away from the O-ring mounted in the seat. This allows gas to flow around the seat and out the nozzle to give the required thrust. During Agena engine operation, the thrust valves are used to control roll errors. After engine burn is terminated, they are used to correct pitch, yaw, and roll errors, and to position the vehicle in the proper attitude for orbital operation. Figure 4-10 is a cutaway view of an individual thrust valve cartridge.

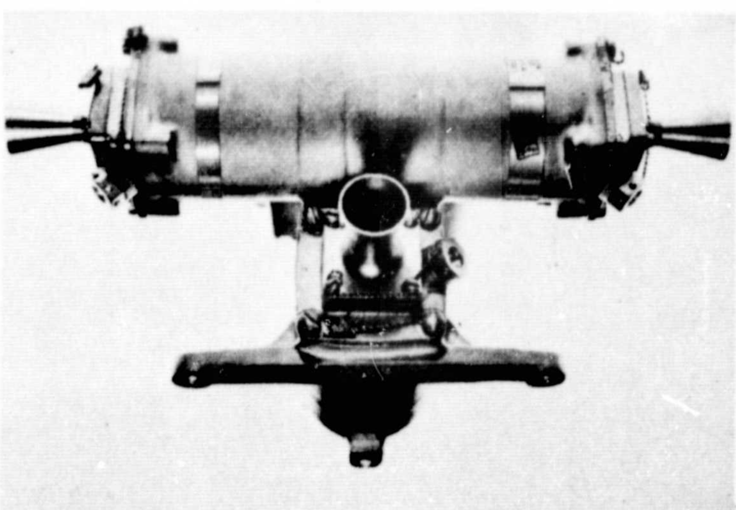


Fig. 4-9 Thrust Valve Cluster

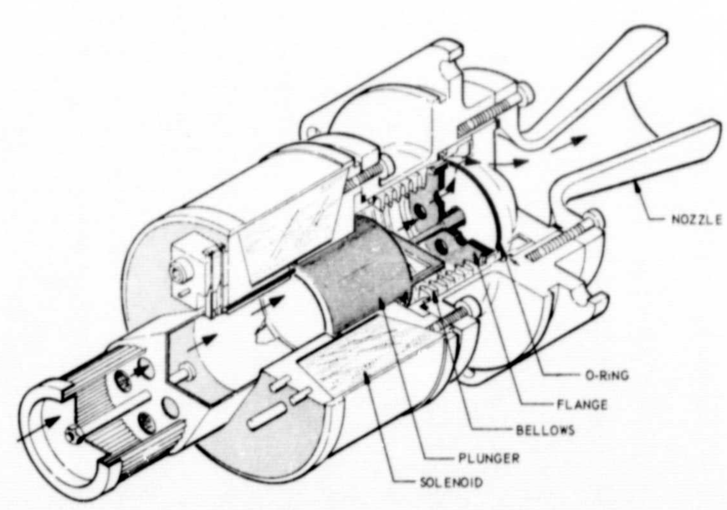


Fig. 4-10 Thrust Valve Cartridge

4.1.4.3 Control Gas Storage Sphere.

LMSC Drawing Number: 1461682
LMSC Specification Number: 1412816
Vendor: Airite Products

This storage sphere has a 2200 cubic inch capacity, is made from titanium, and weighs approximately 21.2 pounds. The sphere has an operating pressure of 3600 psig.

4.1.5 Hydraulic Control System

The hydraulic control system (Fig. 4-11) consists of a hydraulic package, servo actuators, and associated connecting parts. This system gimbals the vehicle engine during engine burn to provide vehicle pitch and yaw attitude control.

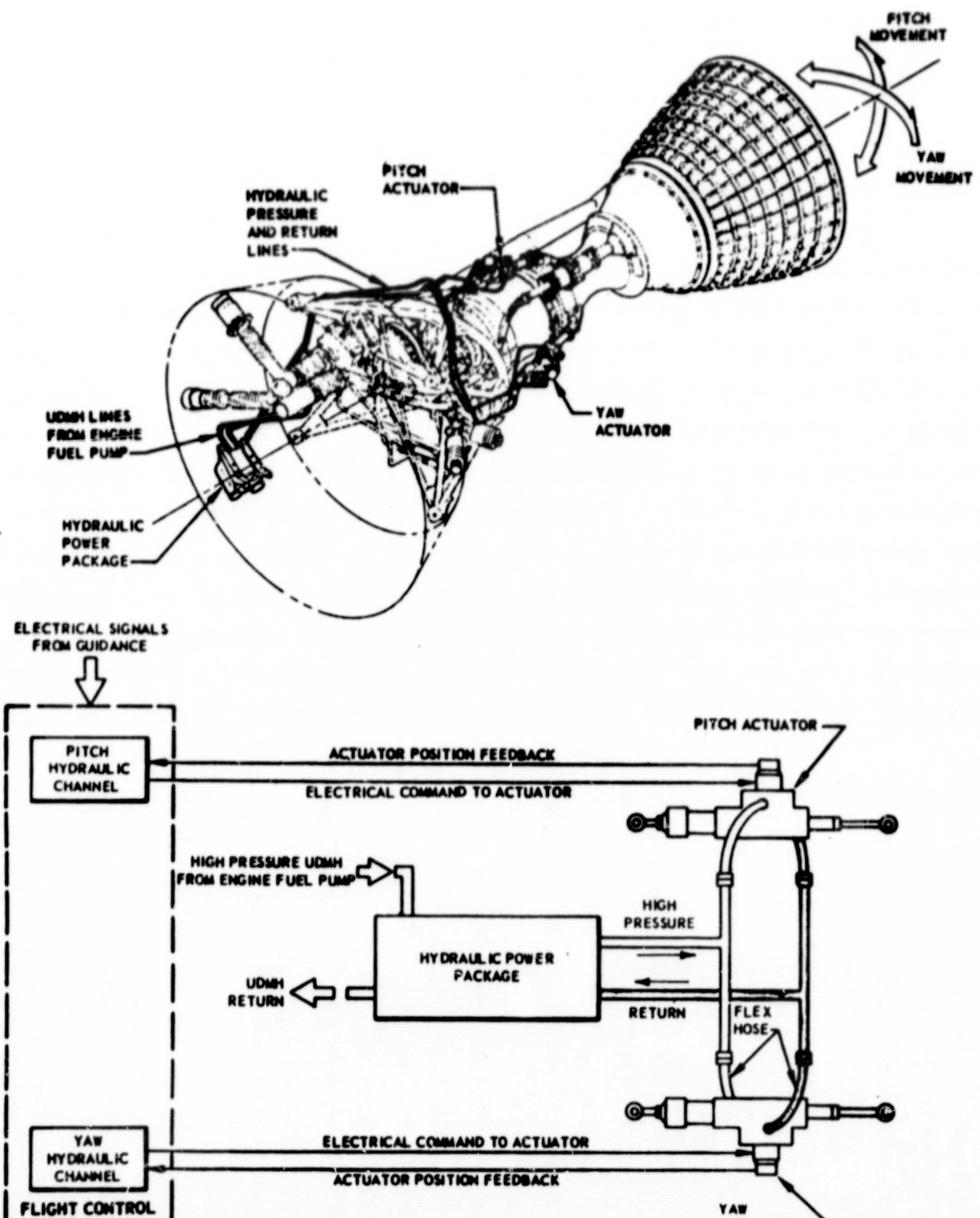


Fig. 4-11 Hydraulic Attitude Control System

4.1.5.1 Hydraulic Power Package.

LMSC Drawing Number: 1461704
LMSC Specification Number: 1412972
Vendor: Lear-Siegler Inc.

The hydraulic power package (Fig. 4-12) consists of an axial piston hydraulic pump driven by a gear motor operated by UDMH fuel bled from the main engine fuel system. An integral cartridge-type fuel strainer ensures a clean fuel supply to the motor. Pressurized oil is supplied to the servo actuators by the piston pump and returned from the actuators to the power package pump inlet port. An integral oil filter cartridge collects the contaminant returning from the actuators. Pump inlet pressure is supplied by a springloaded reservoir that has incorporated into it a mechanical overfill valve to prevent over-pressurizing the low-pressure circuit. An integral pressure-regulating valve in parallel with the servo actuators dissipates the hydraulic power to the pump inlet during operation when the servos are in the null position. The pump bypass flow to the regulating valve is passed through an integral cartridge filter. A pressure transducer and amplifier included on the power package monitor the pump discharge pressure.

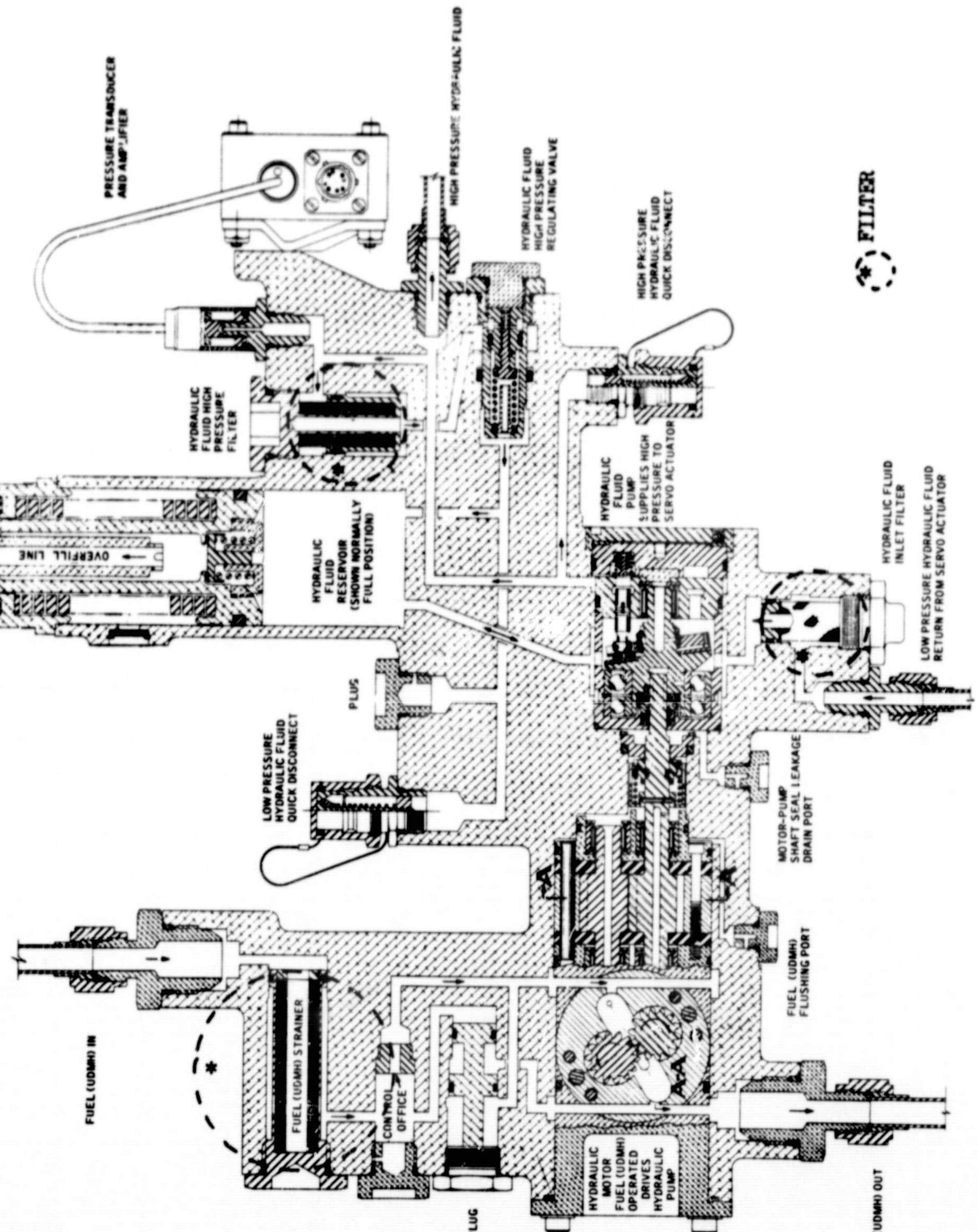


Fig. 4-12 Hydraulic Power Package

4.1.5.2 Servo Actuator.

LMSC Drawing Number: 1561902
LMSC Specification Number: 1037289
Vendor: Moog Servo Controls, Inc.

The servoactuators (Fig. 4-13), each consisting of a polarized electrical torque motor and a two-stage hydraulic power amplifier, drive hydraulic pistons connected to the engine gimbaling system. The polarizing magnetic flux is generated by two permanent magnets arranged in parallel between the upper and lower pole-pieces. The motor armature extends into the air gaps of the magnetic flux circuit and is supported in this position by a flexure tube. The flexure tube acts also as a seal between the electromagnetic and hydraulic sections of the valve. Two motor coils surround the armature, one on each side of the flexure tube. Energizing the motor coils by signals from the FCE causes movement of the flexure tube, which in turn permits the high pressure hydraulic oil to drive the pistons. When a piston approaches the end of its stroke, the hydraulic fluid is forced from the cylinder and flows through the return port located at the end of the cylinder chamber. A snubber is provided which, when contact is made with the end of the chamber, limits the flow to the return port by means of an orifice in the snubber plate. The flow through this orifice allows the piston to continue at a reduced velocity to the end of the cylinder.

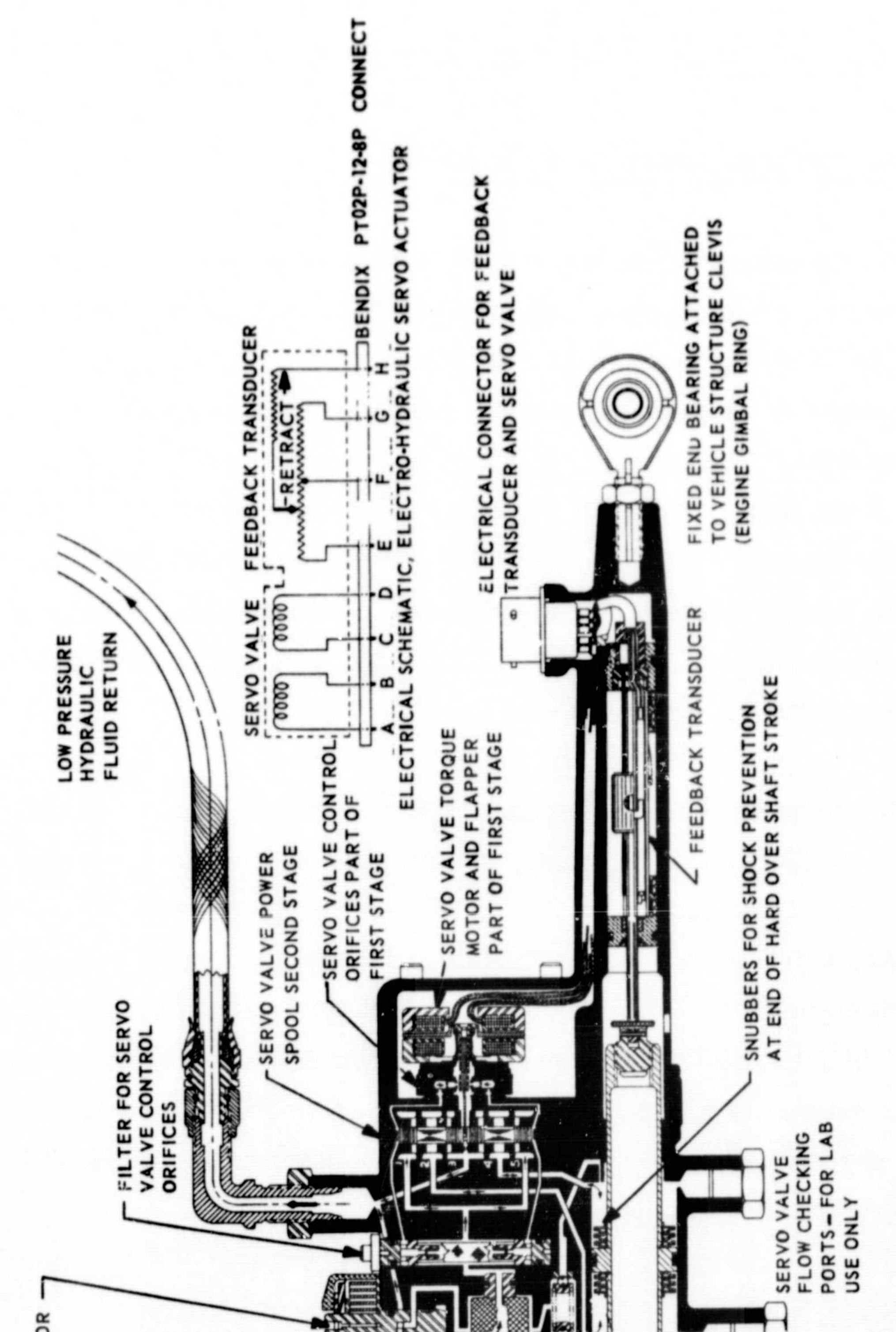


Fig. 4-13 Electro-Hydraulic Servo Actuator (Cutaway View)

4.2 MISSION-PECULIAR GUIDANCE AND FLIGHT CONTROLS EQUIPMENT

4.2.1 Dual Attitude Control System (DACS)

DACS is a mission-peculiar attitude control system developed for a current Agena program with a mission requiring an extended orbit life with active three-axis stabilization. The system, diagrammed in Fig. 4-14, consists of a primary system used during ascent and on orbit, plus a secondary system used as a backup for the primary system on orbit. The primary system consists of a gyro reference assembly (GRA), a horizon sensor assembly (HSA), a velocity control assembly (VCA), and an augmented electronics assembly (AEA), plus the normal Agena pneumatics and hydraulics equipment. The backup system is comprised of a second GRA, a second HSA, and an orbit electronics assembly (OEA), plus a pneumatic attitude control system basically identical to that of the primary system.

The DACS equipment can be considered for mission-peculiar Agena tug use either with the system configured as currently flown or utilizing one of several alternatives. One alternative is known as 1/2 DACS, or SACS (single-attitude control system). This system is merely DACS without the backup orbit system. The remaining alternatives are hybrid systems utilizing the basic inertial guidance system with selected DACS components. With the hybrid systems, the IGS would be used for Ascent and the DACS equipment used either to back up the IGS on orbit or in place of the IGS on orbit. In addition, the DACS horizon sensor can be considered for use with the IGS on orbit to provide an earth reference.

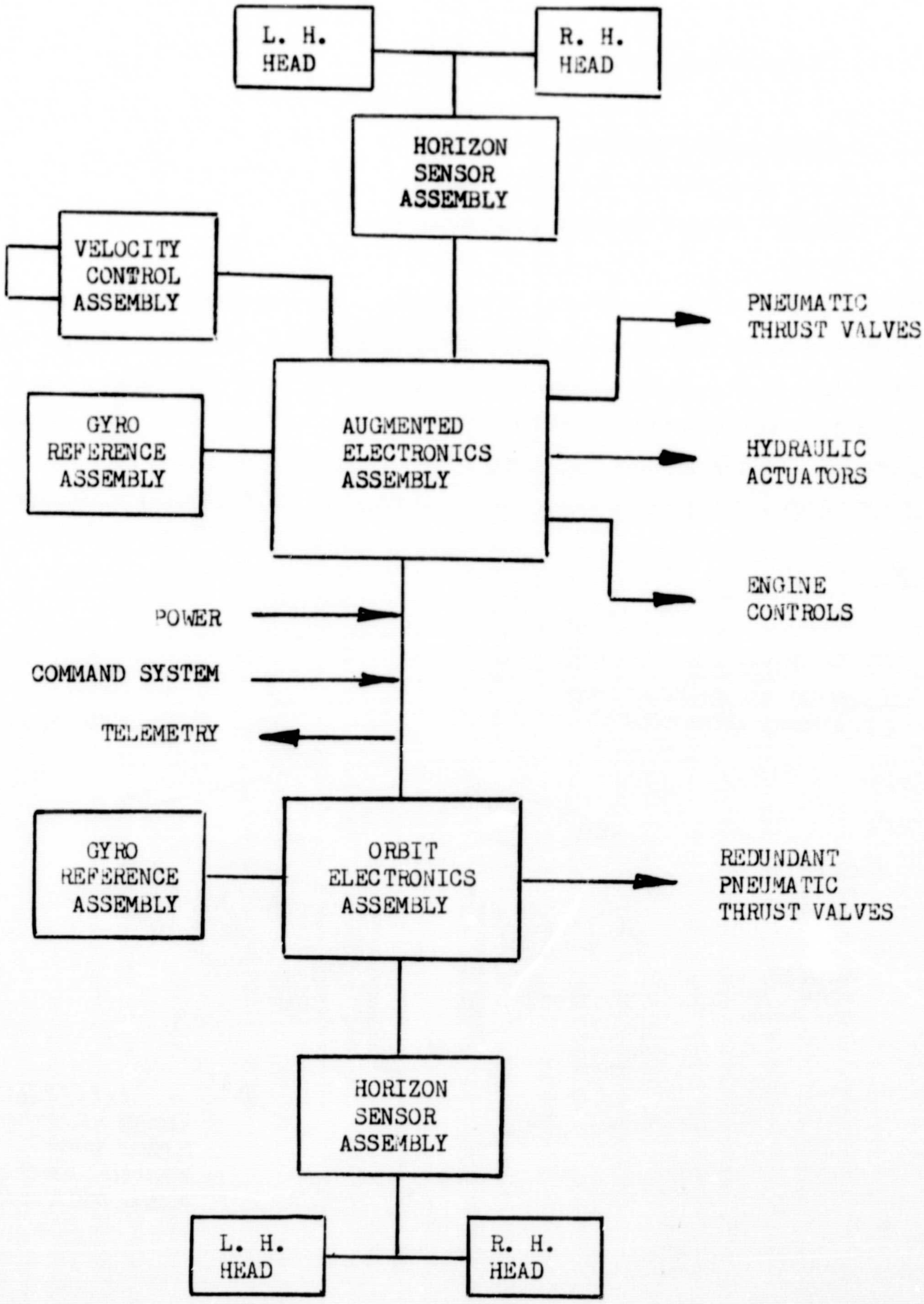


Fig. 4-14 Dual Attitude Control System (DACS)

4.2.1.1 Gyro Reference Assembly (GRA).

LMSC Drawing Number: 1464439

LMSC Specification Number: 1421008

Vendor: Singer-General Precision, Inc.

The GRA (Fig. 4-15) consists of three single-degree-of-freedom, integrating gyros, oriented with the vehicle pitch, yaw, and roll axes and supporting electronics. The unit weighs 22.0 pounds maximum and requires approximately 60 watts of 28-volt unregulated dc power with the unit at 70° F. Each gyro has a gimbal range of ±10 degrees minimum. Under normal operation, the gyros have a maximum non-g-sensitive drift of 0.50 degree/hour and a maximum g-sensitive drift of 3.0 degrees/hour/g.

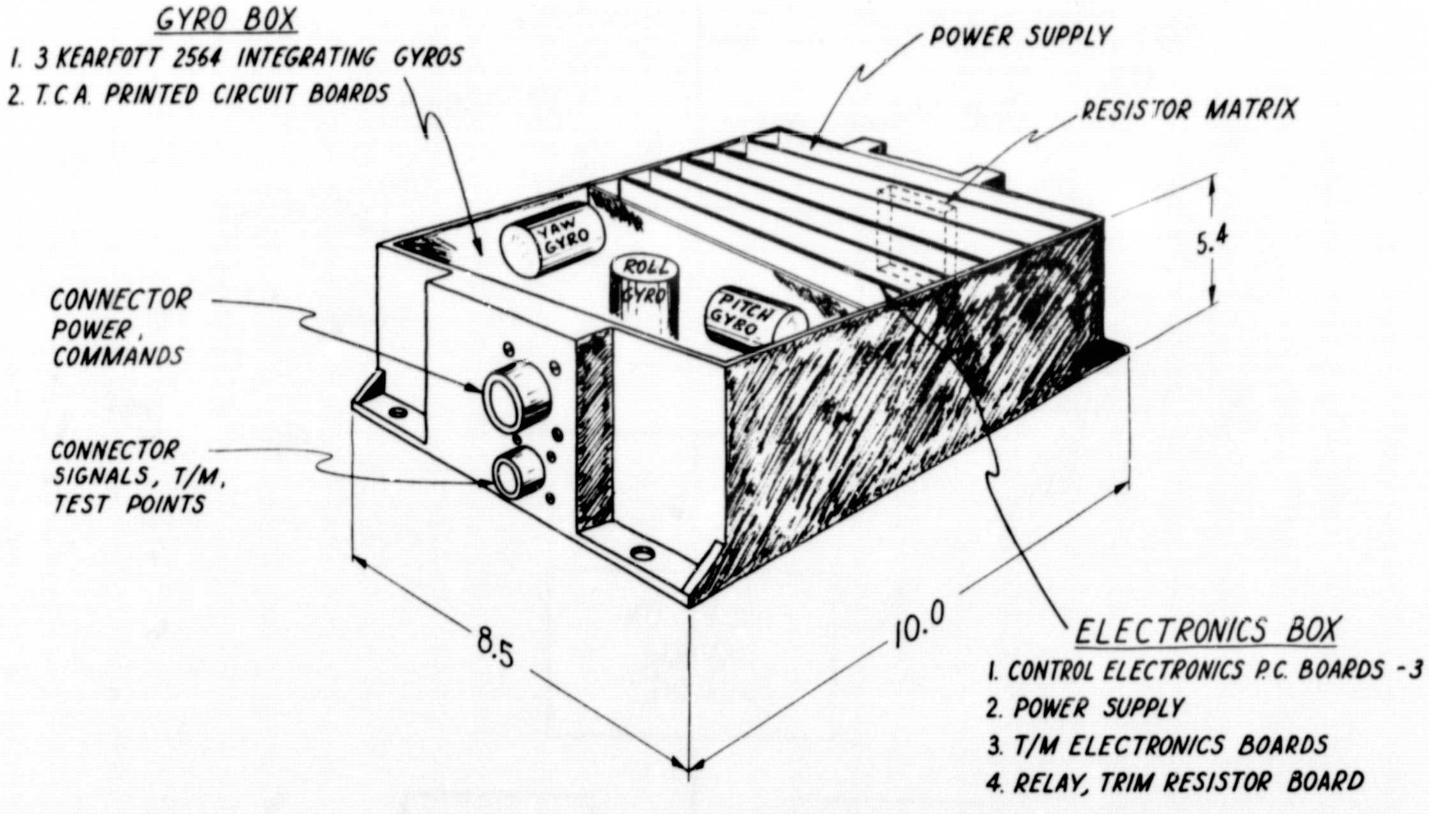


Fig. 4-15 GRA Mechanical Configuration

4.2.1.2 Horizon Sensor Assembly (HSA).

LMSC Drawing Number: 1462041
LMSC Specification Number: 1419268
Vendor: Barnes Engineering

The HSA (Fig. 4-16) consists of two identical infrared sensing heads that scan simultaneously and an electronic signal processing box. The heads scan conically to the left and right of the longitudinal axis of the vehicle. A discontinuity in radiation levels is sensed each time the field-of-view crosses the earth's horizon. The radiation is focused on a detector and the resulting signal is processed by the electronics box into pitch and roll attitude error signals. These signals are used in conjunction with the GRA to maintain the vehicle in the desired orientation. The design includes provisions for selecting various electrical pitch bias angles. The HSA weighs 25 pounds maximum and requires about 20 watts of 28 volt unregulated dc power.

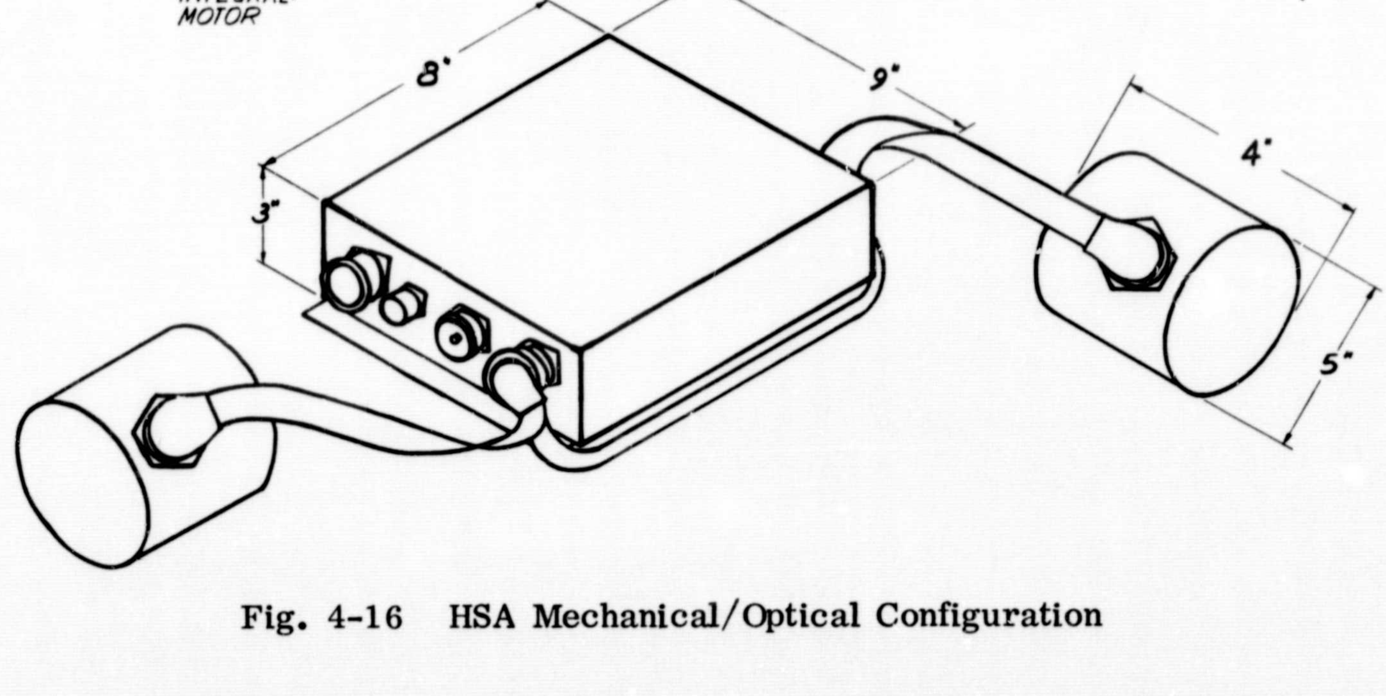


Fig. 4-16 HSA Mechanical/Optical Configuration

4.2.1.3 Velocity Control Assembly (VCA).

LMSC Drawing Number: 1462185
LMSC Specification Number: 1419707
Vendor: Honeywell, Inc.

The VCA (Fig. 4-17) senses vehicle acceleration, integrates this acceleration into velocity, and provides an output signal when the velocity reaches a predetermined value. This output signal is used to initiate engine shutdown.

The VCA consists of a fluid-damped accelerometer, control electronics to process the accelerometer outputs into a digital form indicating changes in vehicle velocity, and a binary counter. All of these components are grouped in a single package, which weighs 8.0 pounds maximum and requires approximately 20 watts of power. The acceleration range of the VCA is from 5×10^{-3} to 7.5 g and the velocity range is from 0.505 to 16,000 feet per second.

As presently designed, the VCA has only a single-burn capability. However, it can be adapted to a multiburn capability by replacing the program plug with a plug that allows the velocity to be gained to be selected by external command.

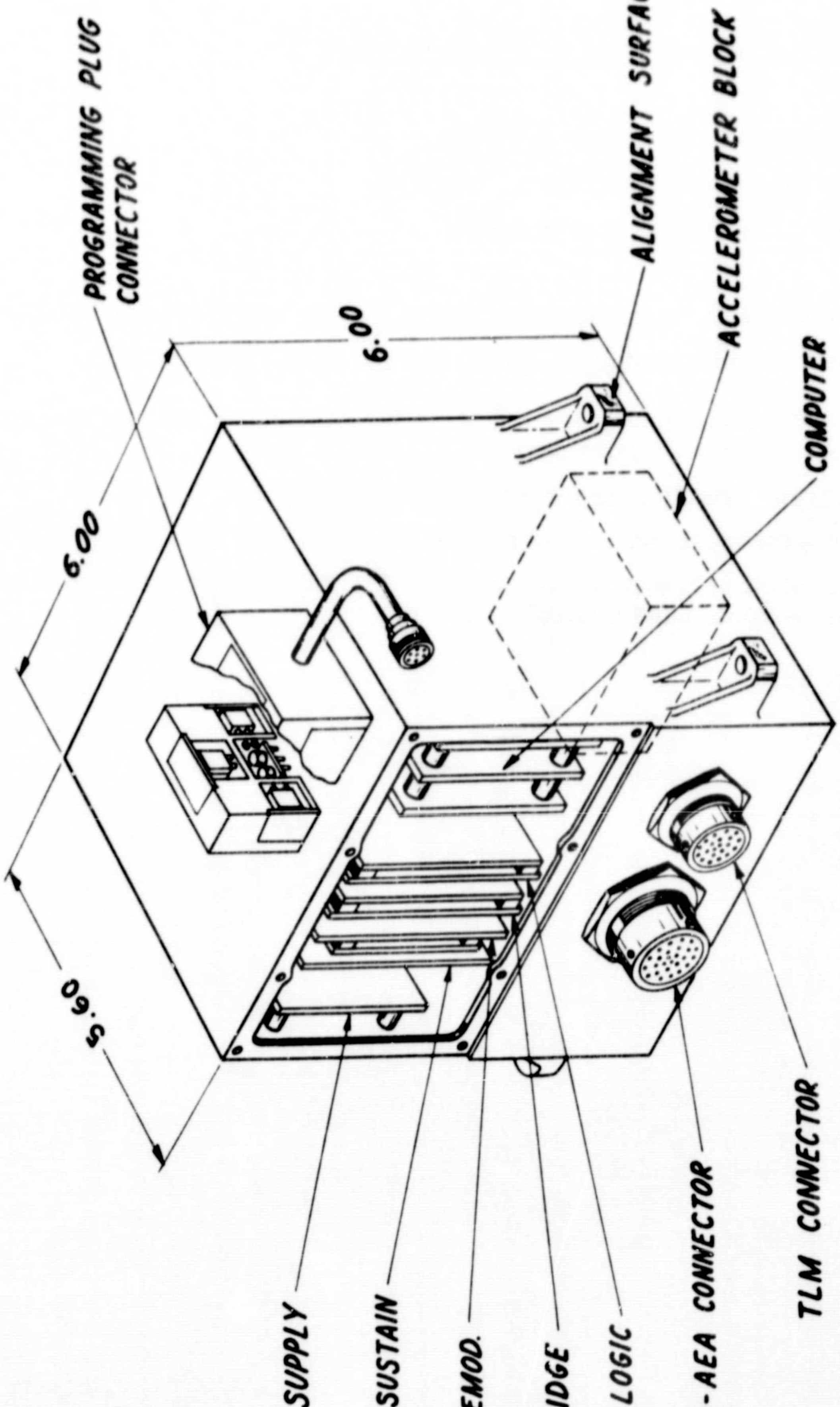


Fig. 4-17 VCA Mechanical Configuration

4.2.1.4 Augmented Electronics Assembly (AEA).

LMSC Drawing Number: 1384937

LMSC Specification Number: 1419710

Vendor: Built in-house by LMSC

The AEA provides the interface electronics for the DACS primary equipment. The unit, weighing 22.0 pounds maximum, performs the following functions:

a. Signal conditioning for inputs to the roll, pitch and yaw pneumatics, and pitch and yaw hydraulics
b. Signal conditioning for HSA inputs to the GRA
c. Engine shutdown signal routing from the VCA
d. Control of power to the primary DACS equipment and switching functions under command control

4.2.1.5 Orbit Electronics Assembly (OEA).

LMSC Drawing Number: 1384938
LMSC Specification Number: 1420831
Vendor: Built in-house by LMSC

The OEA provides the interface electronics for the DACS backup equipment. This unit weighs 19.0 pounds and performs most of the same functions that the AEA performs except there are no circuits for hydraulic attitude control nor for engine shutdown.

4.2.2 A Redundant Orbit Attitude Control System

This attitude control system was developed for an LMSC non-Agena orbiting vehicle, but it incorporates equipment that might be of interest for certain Agena tug mission-peculiar applications. The system is comprised for two redundant halves, each with an inertial reference assembly (IRA), a horizon sensor assembly (HSA), a flight control electronics assembly (FCEA), and a hydrazine thruster system. A schematic of one-half of this attitude control system, showing the system's various functions and interfaces, is shown in Fig. 4-18.

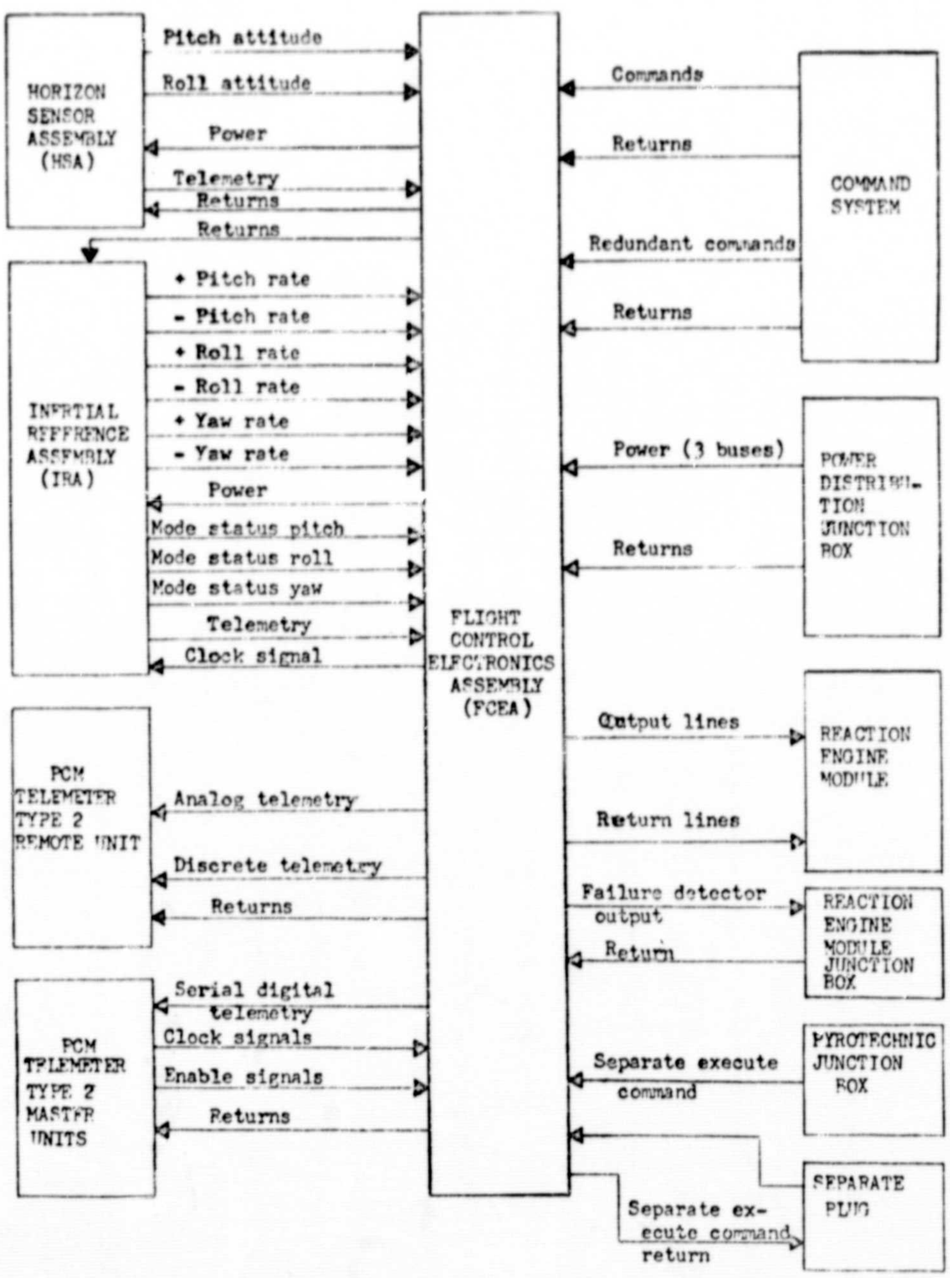


Fig. 4-18 One-Half of a Redundant Orbit ACS

4.2.2.1 Inertial Reference Assembly (IRA).

LMSC Drawing Number: 8100002
LMSC Specification Number: 8100003
Vendor: Honeywell, Inc.

The IRA contains three single-degree-of-freedom, pulse-rebalanced, integrating gyros. The unit requires 50 watts of 28-volt dc unregulated power under normal orbit conditions; it weighs a maximum of 17.75 pounds. The output of each channel is a digital signal providing rate information. Significant performance characteristics are as follows:

a. Rate range: ± 5.6 degrees/sec
b. G-insensitive bias drift: ± 1 degree/hour maximum
c. G-sensitive drift: ± 1 degree/hour/g maximum
d. Scale factor accuracy: ± 0.1 percent

4.2.2.2 Flight Control Electronic Assembly (FCEA).

LMSC Drawing Number: 8100401
LMSC Specification Number: 8100402
Vendor: Built in-house by LMSC

The FCEA processes attitude information from the HSA and rate information from the IRA, and issues the commands to the reaction control thrusters necessary to maintain the proper vehicle attitude. The unit also performs extensive switching functions for power control and maneuvers. The FCEA weighs 30 pounds maximum and requires a maximum of 33 watts of 28-volt unregulated dc power.

4.2.2.3 Horizon Sensor Assembly (HSA).

LMSC Drawing Number: 8100012
LMSC Specification Number: 8100032
Vendor: Barnes Engineering Co.

This is basically the same horizon sensor as that used with DACS.

4.2.3 Control Moment Gyroscope (CMG)

LMSC Drawing Number: 1462520
LMSC Specification Number: 1420188
Vendor: Singer-General Precision, Inc.

The Agena, when placed in a nose-down (or nose-up) position on orbit, is essentially gravity-gradient stabilized by virtue of its moment-of-inertia distribution. However, without some sort of damping, oscillations can build up to appreciable amplitudes as a result of local gravity-field restoring torques. CMGs are employed to damp out these oscillations. Using four CMGs makes it possible to have long-life, three-axis stabilization with a minimum power requirement and no-control gas usage.

This particular CMG is a rate integrating gyro with a single degree of freedom. At operating speed the unit has an angular momentum of 45 x 10^{-6} gram-centimeters squred per second. The gyro gimbal angle is ± 25 degrees about the null. The unit weighs 15.7 pounds and requires 7.5 watts of 115-volt 3-phase 4 Hz power.

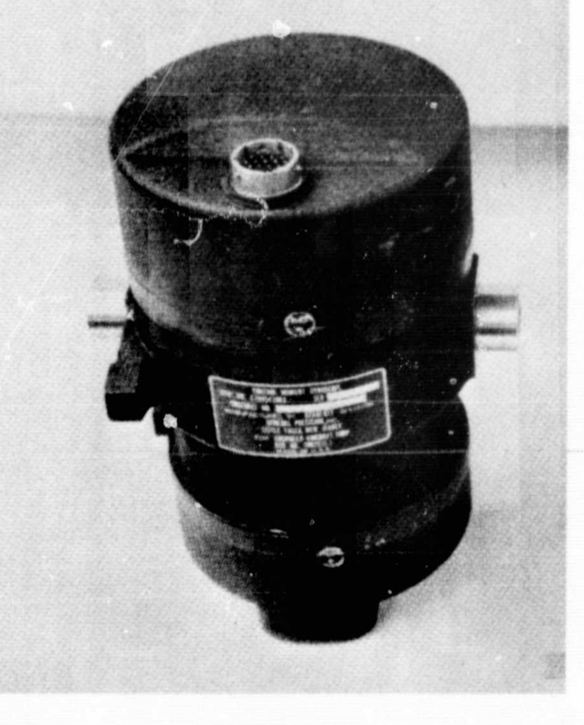


Fig. 4-19 Control Moment Gyro

4.2.4 Timers

4.2.4.1 DI/AN Timer.

LMSC Drawing Number: 1464798
LMSC Specification Number: 1417579
Vendor: DI/AN Controls Inc.

This timer furnishes 12 sequentially timed latching relay outputs. Each interval can be varied up to 8192 seconds in 0.5-second intervals. The timer is programmed by jumper plugs being inserted into a matrix board. The timer consists of four printed circuit boards and a metal plate holding the relays. The majority of the circuitry consists of core transistor logic elements. The unit weighs 4.75 pounds and dissipates 0.75 watt.

4.2.4.2 Type 13 Backup Timer.

LMSC Drawing Number: 8100177
LMSC Specification Number: 8100178
Vendor: Adcole Corporation

On command this timer initiates a 540-second countdown period. At the end of the 540 seconds, if a reset command has not been received, the timer issues a 28-volt, 130-millisecond output pulse. The unit weighs 2.0 pounds maximum.

4.2.5 Attitude Recovery Systems

Three attitude recovery systems are used on LMSC vehicles, all of which utilize basically the same equipment. One such system is known as BUSS (back-up stabilization system). The BUSS is activated by ground command and is independent of the remainder of the vehicle attitude control system. The system consists of a magnetometer, a rate gyro, an electronics box, a junction box, and a separate pneumatic control system. The BUSS pneumatic control system consists of a gas supply, a pressure regulator, and six thrust valves. The following paragraphs describe the BUSS equipment.

4.2.5.1 Magnetometer.

LMSC Drawing Number: 1461662
LMSC Specification Number: 1412854
Vendor: Schonstedt Instrument Co.

This unit measures the intensity of the magnetic field of the earth along each of the three axes of the vehicle and provides three analog signals to the pneumatic control electronics assembly representing these intensities. The magnetometer weighs 4.0 pounds maximum and dissipates 3.0 watts maximum.

4.2.5.2 Rate Gyro.

LMSC Drawing Number: 1461681
LMSC Specification Number: 1412906
Vendor: Nortronics

This gyro is used to provide roll rate information to the pneumatic control electronics. The unit, with a rate range of ±6 degrees per second, provides an analog output signal proportional to the vehicle roll rate. The gyro requires a maximum of 7 watts during normal operation and weighs less than 2.0 pounds.

4.2.5.3 BUSS Pneumatic Control Electronics.

LMSC Drawing Number: 1387785
LMSC Specification Number: 1419901
Vendor: Built in-house by LMSC

When the backup stabilization system is activated, this unit processes the three magnetic-field intensity signals from the magnetometer and the roll-rate signal from the roll-rate gyro and modulates the pneumatic gas valves as necessary to recover and maintain the appropriate vehicle altitude. This electronic package weighs 5.5 pounds maximum.

4.2.5.4 Pneumatic Regulator.

LMSC Drawing Number: 1461708
LMSC Specification Number: 1412996
Vendor: Sterer

The BUSS pneumatic regulator is a single-stage regulator that provides 110 to 135 psig control gas to the thrust valves from a 3600 psi maximum supply. The unit weighs 2.75 pounds maximum.

4.2.5.5 Thrust Valves.

LMSC Drawing Number: 1462554

LMSC Specification Number: 1420742

Vendor: Built by both Weston Hydraulics Limited and Sterer Engineering

These thrust valves are identical to the units used in the basic pneumatic system, except that they are mounted separately rather than in clusters of three with a common manifold.

4.2.6 Earth Sensor

LMSC Drawing Number: 1384911
LMSC Specification Number: 1419772
Vendor: Built in-house by LMSC

The earth sensor (Fig. 4-20) is an infrared device used to regain an earth roll reference at the end of a drift averaging roll technique (DART) maneuver. This maneuver, typically performed on synchronous equatorial type missions during the long coast up to synchronous altitude, consists of rolling the vehicle to cancel drifts in the pitch and yaw gyros (and also to equalize thermal loads). The sensor has a fixed lens and detector with a 1 ±1/4 degree field-of-view; it is accurate within ±0.6 degree from synchronous altitude. The unit weighs 1.2 pounds and requires 1.5 watts of power.

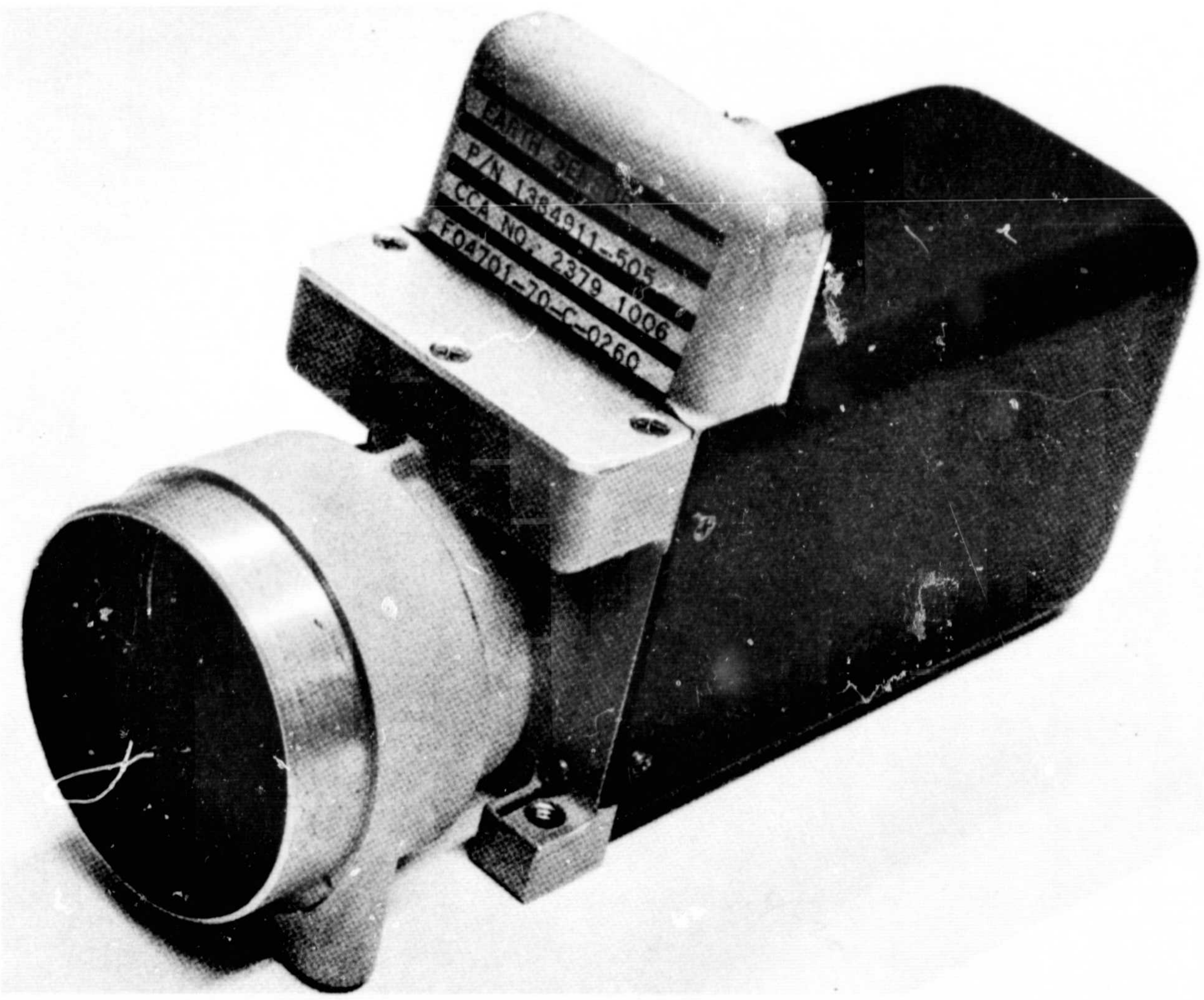


Fig. 4-20 Earth Sensor

Section 5

TELMETRY, TRACKING, AND COMMAND SYSTEM

Section 5
TELEMETRY, TRACKING, AND COMMAND SYSTEM

5.1 BASIC VEHICLE TELEMETRY, TRACKING, AND COMMAND SYSTEM

Figure 5-1 shows the minimum telemetry, tracking, and command system required for the basic Agena tug vehicle. The basic system provides only for the transmission of vehicle data; it includes no equipment specifically for tracking or command. Computer data and vehicle instrumentation data are encoded by the Type 4 PCM telemeter. The telemeter can either modulate a UHF transmitter directly or via a subcarrier in a baseband assembly. The remainder of the system consists of an antenna and a Type 14 RF switch. The telemeter and the RF switch are described in this section and the available baseband assemblies, transmitters, and antennas are described in the section on mission peculiar telemetry, tracking, and command equipment.

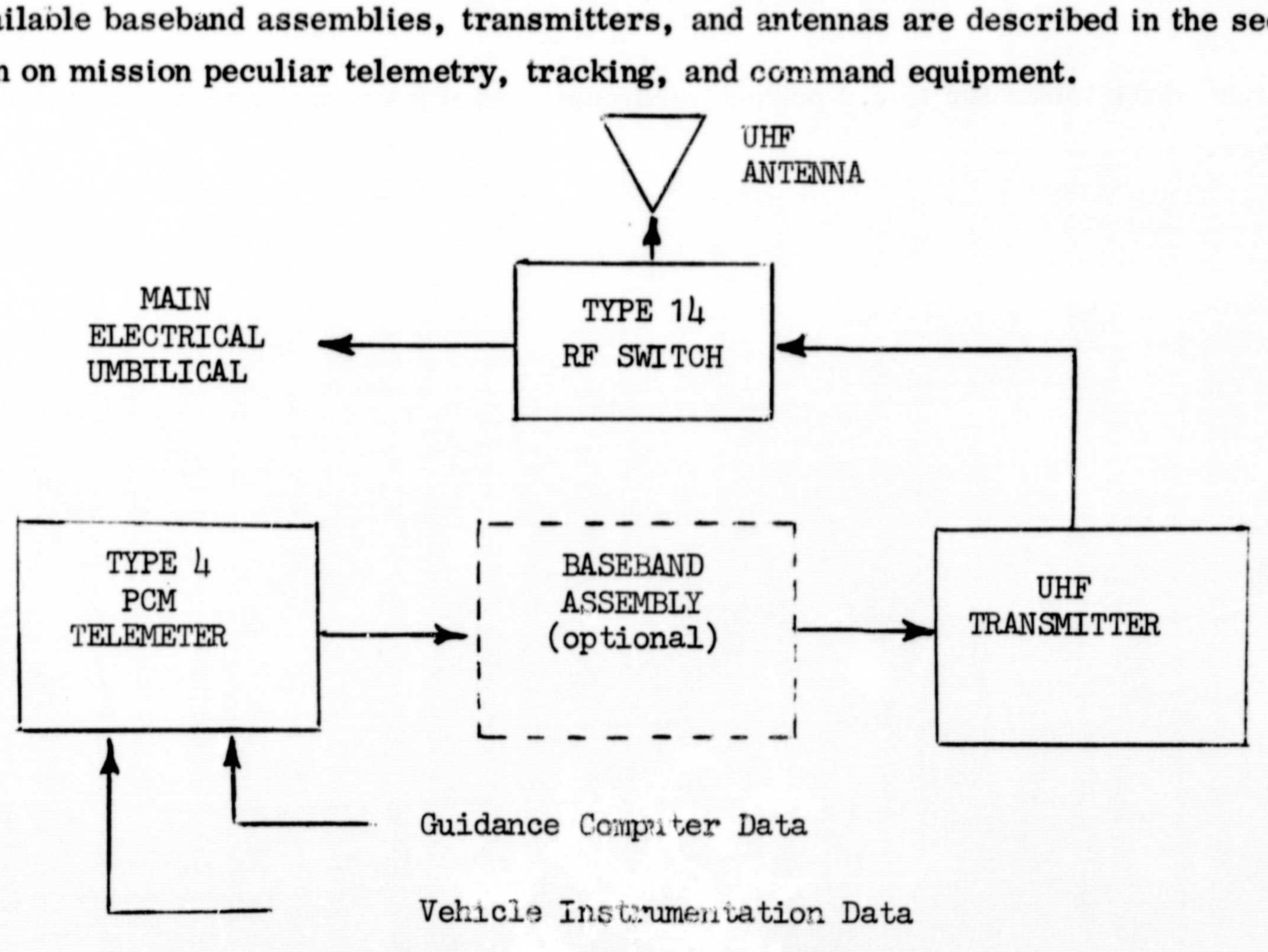


Fig. 5-1 Basic TT&C System

5.1.1 PCM Telemeter, Type 4

LMSC Drawing Number: 1460965
LMSC Specification Number: 1420766
Vendor: Spacecraft Inc.

This unit is a pulse-code-modulated (PCM) telemeter that is compatible with the guidance computer; it is used to transmit vehicle data. The telemeter accepts analog, bilevel, and direct digital inputs, converts analog signals to digital form, and formats and combines all inputs into a digital bit stream with approximately 200 channels of data.

The format for the Type 4 PCM telemeter contains a main frame of 32 eight-bit words, which are sampled at 244 samples per second for a total of 62,500 bits per second. The format also includes nine subframes which provide various sample rates.

Weight of the telemeter is 4.0 pounds maximum, and it requires about 7.0 watts of power.

5.1.2 RF Switch, Type 14

LMSC Drawing Number: 1462071
LMSC Specification Number: 1419552
Vendor: Transco Products, Inc.

The Type 14 RF switch is a single-pole, double-throw, fail-safe coaxial device used for transferring RF energy between two loads. The nominal dimensions of the unit are 1.1 by 2.75 by 3.25 inches; it weighs less than 0.6 pound.

The switch is energized by application of unregulated 28-volt power. Removal of power causes the switch to return to the unenergized position. The system is made fail-safe by using the unenergized position for the primary circuit.

The operating frequency of the switch is 20 MHz through 6000 MHz. The maximum power handling capability for a continuous signal is 20 watts average power. Insertion loss is less than 0.25 dB.

5.2 MISSION-PECULIAR TELEMETRY, TRACKING, AND COMMAND EQUIPMENT

5.2.1 Spacecraft PCM Telemeter Sets

LMSC Drawing and Specification Numbers:

Program	Master Unit		Remote Units	
	Drawing	Specification	Drawing	Specification
A	1462182	1419733	1462182	1419733
B	8100031	8100028	8102068	8100029

Vendor: Spacecraft Inc.

Each telemetry set consists of a master PCM telemeter and several separate submultiplexers. The sets sample analog, discrete, and serial digital data input signals in one of several programmable formats; convert the samples into representative serial binary pulse codes; and time-division multiplex the codes into a serial non-return-to-zero-level (NRZ-L) PCM output at various selectable bit rates up to 256 kilobits per second. This type of telemeter set provides an extremely large capacity for both Agena and payload telemetry data. Figure 5-2 is a block diagram of the system used by Program A, which consists of two master units (the second master is a redundant backup) and four remote units. The six units used by Program A weigh a total of 83.5 pounds.

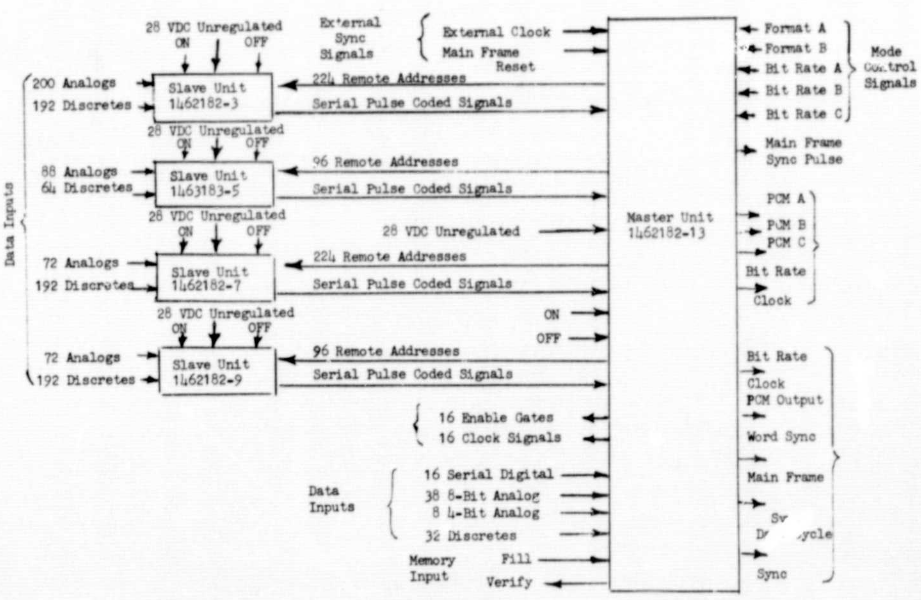


Fig. 5-2 PCM Telemeter, Type 1

5.2.2 Motorola PCM Telemeter Sets

LMSC Drawing and Specification Numbers:

Program	Master Unit		Submultiplexers	
	Drawing	Specification	Drawing	Specification
A	1462034	1419280	1462035, 1462036	1419281, 1419282
B	1462592	1420955	1462593	1420956

These telemeter sets provide for the coding of analog, digital, and discrete data from payload equipment and instrumentation into a serial non-return-to-zero-level (NRZ-L), time multiplexed, PCM format.

The master unit used by Program A has a main frame of 128 eight-bit words, each sampled at 125 samples per second for data transmission, and 7.8 samples per second for data storage. The Program B master unit has a main frame of 32 eight-bit words sampled at 125 samples per second. Both master units have two identical, redundant telemetry modules, with switching control to enable operating of one module at a time based on external command. The master units weigh 17.0 pounds maximum for the Program A configuration and 15.5 pounds maximum for the Program B configuration.

The submultiplexers are separate, remotely located units that encode analog and discrete data into subframes for the master telemeter. Power and control signals for the submultiplexers are provided by the master unit. The units weigh from 7.5 to 18.5 pounds, depending on configuration.

5.2.3 PCM Telemeter, Type 3

LMSC Drawing Number: 1462271
LMSC Specification Number: 1419936
Vendor: Spacecraft, Inc.

The PCM Type 3 telemeter accepts data inputs in the form of high-level analog (0-5 vdc), low-level analog (0-50 mv), and direct-digital format. The unit processes the inputs into an NRZ-L time multiplexed PCM format. The PCM format consists of eight-bit, quantitized, digital, words with the most significant bit first in time relationship. The unit contains a main frame of 32 digital eight-bit words and a subframe containing 128 digital eight-bit words. This telemeter is produced in a choice of two sample rates of 256 samples per second for the main frame and 16 samples per second for the subframe, resulting in a total of 65,536 bits per second. The second configuration (-3) has sampling rates of 64 samples per second for the main frame and 4 samples per second for the subframe for a total of 16,384 bits per second. Both units provide internally generated calibrate and sync signals and frame identification; each weighs 4 pounds maximum.

5.2.4 PCM Telemeter Type 5

LMSC Drawing Number: 1387730
LMSC Specification Number: 1420951
Vendor: Built in-house by LMSC

This telemeter is a specialized unit designed to provide telemetry and control functions for an experimental payload. The telemetry and control functions in the unit are completely independent.

The telemetry function utilizes a main frame with 72 eight-bit words sampled at 444.4 samples per second. Of the 72 words, two are used for sync, 64 are used for 16 analog sensor data inputs (each supercommutated at four words per frame), one word provides a 32-channel subframe, two words are for digital discretes, and two words are for timing data.

The control function of the Type 5 PCM telemeter contains a pseudo-decoder capable of accepting input signals from a command receiver and decoding these signals into eight commands.

The unit weighs a maximum of 20.0 pounds. With both telemeter and control functions operating, the unit dissipates a maximum of 25 watts of power.

5.2.5 FM/FM Ascent Telemeter

LMSC Drawing Numbers: 8100465 (15 channels)
1462858 (3 and 5 channels)

LMSC Specification Number: 8100464

Vendor: Dorsett Electronics, Inc.

This telemeter is used primarily to transmit high-frequency vibration and acoustic data. The basic unit consists of 15 data channels; seven are IRIG constant bandwidth channels and eight are IRIG proportional bandwidth channels. The 15 channels are summed into a single output which is used to modulate a transmitter. The design utilizes plug-in voltage-controlled oscillators (VCOs) and the three-channel and five-channel configurations are the basic unit with the remaining VCOs removed. The maximum weight of the telemeter with all 15 channels is 7.4 pounds.

5.2.6 Cubic UHF Transmitters

LMSC Drawing and Specification Numbers:

Type	Drawing	Specification
13	1462051	1419520
16	1462268	1420077
19	1460958	1420763
–	8100181	8100182

Vendor: Cubic Corporation

These transmitters are all constructed basically the same. All are frequency-modulated (FM) except the Type 19, which is phase-modulated. All provide an RF output of 2.0 watts minimum except that the Type 13 can be procured both in 2-watt and 3-watt versions. The units operate in the 2200 to 2300 MHz frequency range, with a frequency stability of plus or minus 0.003 percent. Each transmitter weighs a maximum of 4.0 pounds and dissipates about 31 watts of power.

5.2.7 UHF/PM Transmitter, Type 20

LMSC Drawing Number: 1462587
LMSC Specification Number: 1420950
Vendor: Motorola, Inc.

This unit is a phase-modulated transmitter that operates in the 2200 to 2300 KHz fequency range and has an RF output of 10 watts minimum. The transmitter has a modulation sensitivity that is field adjustable from 0.2 to 2.0 radians per volt. Weight of the unit is 13.0 pounds and it requires 120 watts maximum of 28-volt unregulated dc power.

5.2.8 Communications Transponder Sets

LMSC Drawing and Specification Numbers and Vendors:

Program	Nomenclature	Drawing	Specification	Vendor
A	Transponder Set	1462198	1419742	General Dynamics Electronics
B	Transponder Set	8100089	8100088	General Dynamics Electronics
C	Transmitter Receiver-Demod. Baseband	1462282 1462283 1462284	1420055 1420056 1420057	General Dynamics Electronics
D	Transmitter Receiver-Demod. Baseband	1462031 1462033 1462032	1419277 1419279 1419278	Motorola Inc.
E	Transmitter Receiver-Demod. Baseband	1462031 1462589 1462590	1419277 1420952 1420953	Motorola Inc.

Each of these sets consists of three separate units: a receiver-demodulator, a baseband assembly, and a transmitter. The sets are space ground link system (SGLS) compatible and are capable of receiving ranging signals from ground stations and transmitting them back, receiving command signals for orbital execution, and transmitting telemetry data to ground station.

The receiver-demodulator unit in each set operates at a preselected frequency in the range of 1762 to 1842 MHz. The unit is capable of acquiring and phase-locking onto an RF carrier phase modulated by pseudo-random noise (PRN) ranging data and command data. The PRN ranging signal is demodulated from the RF carrier and supplied to the baseband to be transmitted back to the ground station. The command data are demodulated into a digital output. The receiver-demodulator also provides a coherent drive output to the transmitter which represents a specific ratio of the received RF carrier frequency. The receiver-demodulator weighs a maximum of 9.0 pounds.

The baseband assembly accepts two telemetry data inputs and the ranging code from the receiver-demodulator and produces a composite baseband signal by means of

frequency multiplexing and a summing device for modulation of the transmitter carrier. One of the two data channels utilizes a 1.024 MHz subcarrier and the second a 1.7 MHz subcarrier. The baseband assembly weighs a maximum of 4 pounds for the General Dynamics configurations and 6 pounds for the Motorola versions. The transmitter in each set provides a phase-modulated RF output of 2.0 watts minimum in the frequency range of 2200 to 2300 MHz, and is capable of operating in a coherent or noncoherent mode. In the coherent mode, the transmitter operates at a frequency proportional to the frequency of the received RF carrier. The transmitter weighs a maximum of 7.0 pounds for the unit supplied by General Dynamics and 7.5 pounds for the unit supplied by Motorola.

5.2.9 Command Receiver-Demodulators, Types 2 and 3

LMSC Drawing and Specification Numbers:

Type	Drawing	Specification
2	1462017	1419160
3	8100093	8100092

Vendor: Conic Corporation

These command receiver-demodulators are controlled by a phase-modulated RF carrier in the 374 to 376 MHz frequency range that has been modulated by a digital command message. The command messages consist of bursts of specific subcarrier frequencies. Four subcarrier frequencies are used, each representing a different message bit. The units demodulate each command bit and provide a specific pulse output pattern over seven output lines. The maximum bit rate is 1000 bits per second.

The maximum weight of this unit is 3.0 pounds. The unit requires a maximum of 0.7 watt of 28-volt unregulated dc power in the standby mode and 1.1 watts when interrogated.

5.2.10 Baseband Assembly, Type 2

LMSC Drawing Number: 1460959
LMSC Specification Number: 1420764
Vendor: Cubic Corporation

The Type 2 baseband assembly accepts two PCM input signals, each of which biphase modulates a subcarrier. The subcarriers are combined into a composite frequency multiplexed output. The frequencies of the two subcarriers are 1.024 MHz and 1.7 MHz.

The nominal dimensions of the unit are 1.76 by 3.63 by 5.21 inches and the nominal weight is 2.0 pounds. The unit has three major functional sections: the oscillator/modulator, summing amplifier/output driver, and regulator and power control.

5.2.11 C-Band Beacon Transponder, Type 10

LMSC Drawing Number: 1460950
LMSC Specification Number: 1417285
Vendor: Motorola, Inc.

This transponder is designed to operate in conjunction with a ground radar to allow a tracking station to determine range, range rate, and pointing angle information. The system operates in the 5400 to 5900 MHz range and is dependent upon the reception of a two-pulse transmission consisting of an address pulse followed by the main radar pulse. Interrogation and reply of the beacon transmitter is determined by the spacing between the address pulse and the main radar pulse. The transponder transmits a single pulse in response to each pair of correctly-spaced received interrogating pulses. A circulator in the transponder permits the use of a single antenna for the transmit and receive functions.

The transponder is a single unit weighing 3.20 pounds maximum. Power dissipation of the unit is 18 watts maximum operating at 410 pulses per second.

5.2.12 Tape Recorders

Magnetic tape recorders are in common use on Agena programs recording of telemetry data while out of range of a tracking station. Several different recorders are used, with various different record times, reproduce times, and frequency responses. The characteristics of several recorders presently used are listed in Table 5-1.

Table 5-1

TAPE RECORDER CHARACTERISTICS

Type	21	27	28	29	32
Drawing	1464846	1462181	8100095	5507100	1462624
Specification	1417698	1419734	8100094	1420824	1421428
Vendor	Leach	Echo Science	Echo Science	LMSC	Odetics
Weight (max. lbs.)	10.0	16.5	16.5	12.0	17.0
Rec. Time (min)-Normal	185 ± 5	90	60^{+5}_{-0}	10^{+2}_{-0}	404 *
-High Speed	-	45			101
Repro. Ratio-Normal	26/1	8/1	5-1/3 / 1	1/1	8/1
-High Speed	-	4/1		-	2/1
No. Data Channels	2	1	1	1	1
Freq.Response-Normal	30 Hz	32,000 bps	48,000 bps	62,500 bps	64,000 bps
-High Speed		64,000 bps	-	-	256,000 bps

* Automatically shutoff after 115 minutes unless overrid by command.

5.2.13 Command Decoders

LMSC Drawing and Specification Numbers:

Type	Drawing	Specification
9	1342192	1412916
22	1379142	1417270
23	1379143	1419679

Vendor: Built in-house by LMSC

The Type 22 and Type 23 decoders are similar units and both provide for an output of 39 realtime discrete commands plus a binary command. The Type 22 decoder has a five-bit binary command output and the Type 23 unit has an 11-bit binary command output. Both are used to decode digital commands from both 375 MHz command receivers and SGLS receiver-demodulators. Both units weigh a maximum of 2.25 pounds.

The Type 9 decoder is a single-word, single-output-function message decoder. The makeup of the command word is determined by the wiring of a pattern plug. This unit weighs 2.0 pounds maximum.

5.2.14 Extended and Minimal Command Systems

Part and Interface Specification Numbers:

Program	Nomenclature	Part No. (G. E.)	Interface Specification (G.E./LMSC)
A	Extended Command System (ECS)	7638786	B117628
	Remote Decoder	7642204	
	Minimal Command System (MCS)	7638725	
B	Extended Command System	7642325	
	Minimal Command System	7642435	

Vendor: General Electric Aerospace Electronics (supplied as GFE to LMSC)

This type of command system is used on vehicles with extended orbit life to provide an extensive secured control capability for the satisfaction of both ascent vehicle and payload requirements. The systems provide for both realtime command decoding and for command programming of sequences to be performed at specified later times.

These units are designed to decode inputs from both SGLS UHF transponder sets and from 375 MHz backup command receivers. Event programming is accomplished by use of time codes included in the commands. Both the ECS and MCS units contain clocks and received commands are stored by the command systems until the coded times are reached.

Extensive redundancy is included in the design of these systems to assure a long orbit life. The ECS contains redundant decoders to allow paralleling of commands and the MCS provides an additional backup to permit satisfying primary mission requirements in the event of ECS failure.

The remote decoder is used in conjunction with the ECS for the issuance of ascent discretes. This decoder has no provision for realtime commands and is only used to decode commands programmed on the ECS.

Agena vehicles using this type of command system are particularly adaptable to automatic vehicle systems checkout. A ground computer can be programmed to control the vehicle through the command sys em during test, and also to limit check vehicle data as the system test proceeds.

5.2.15 Antennas

Antennas available for mission-peculiar use include a selection of antennas currently being flown on various ongoing Agena and similar LMSC programs, plus an assortment of high-gain unfurlable dish antennas that LMSC has developed for a variety of users.

A selection of the qualified antennas used on current Agena-type programs, together with LMSC drawing and specification numbers, is as follows:

Nomenclature	Drawing	Specification
S-Band Antenna, Type 7	1385964	1419934
S-Band Antenna	8100131	8100130
UHF Antenna, Type 4A	1386531	1420125
UHF Antenna, Type 28	1387523	1420990
UHF Antenna, Type 25	1374901	1417249
375 MHz Antenna	8100169	8100170
C-Band Antenna, Type II	1397131	1414818

The Type 7 and the 8100131 antennas are both one-quarter wavelength, monopole, omnidirectional, linear-polarized antennas designed to operate within the frequency range of 1750 to 2300 MHz. The second of the two differs from the first in that it has a threaded base for the installation of an RF coupler for ground test purposes.

The Type 4A and Type 28 antennas are used for reception in the 1740 to 1840 MHz frequency range and for transmission in the 2200 to 2300 MHz frequency range. The Type 4A mounts flush with the Agena forward section skin. The Type 28 antenna has a crossed dipole feed with a 19-inch diameter semi-flat reflector.

The Type 25 and the 8100169 antennas are similar units designed to be used with 375 MHz command receivers. Both are foldout monopole antennas.

The Type II C-Band antenna is a flush-mounted unit designed to be operated with the C-Band beacon transponder.

The high-gain unfurlable dish antennas developed by LMSC for use on spacecraft have included a wide variety of sizes, up to the 50-foot-diameter development model shown in Fig. 5-3. The most recent LMSC project in this area has been the development of a 30-foot-diameter flex-rib antenna reflector for the NASA ATS F&G spacecraft. This reflector is a skin-stressed, rigid-ring base, flexible radial beam parabola, and has 48 flexible rib assemblies and a copper-coated dacron mesh RF reflective surface. It is unfurled in space from a doughnut-shaped package approximately 9.0 inches high with a 78-inch outside diameter and a 60-inch inside diameter. Figure 5-4 shows this antenna concept deployed in space.

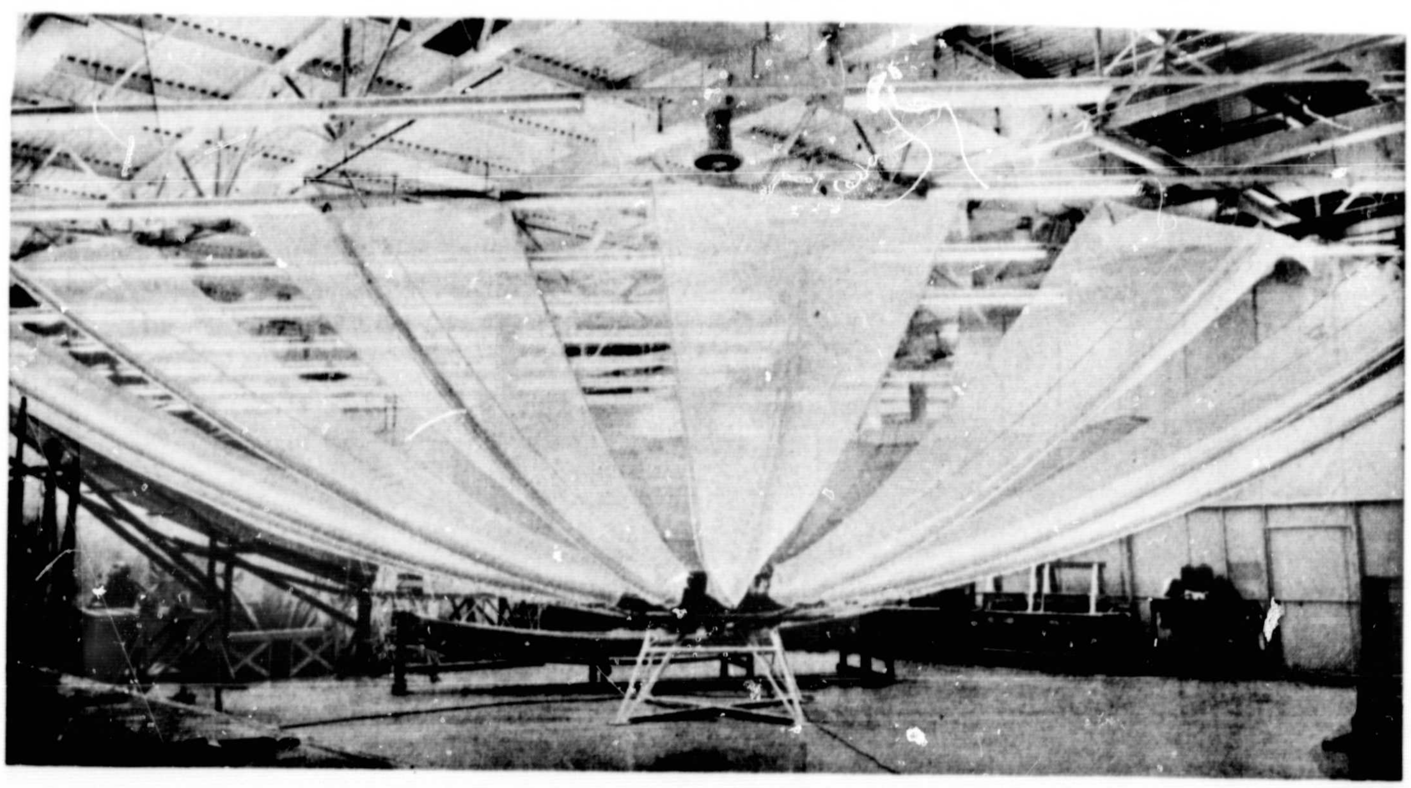


Fig. 5-3 50-Foot Parabolic Antenna

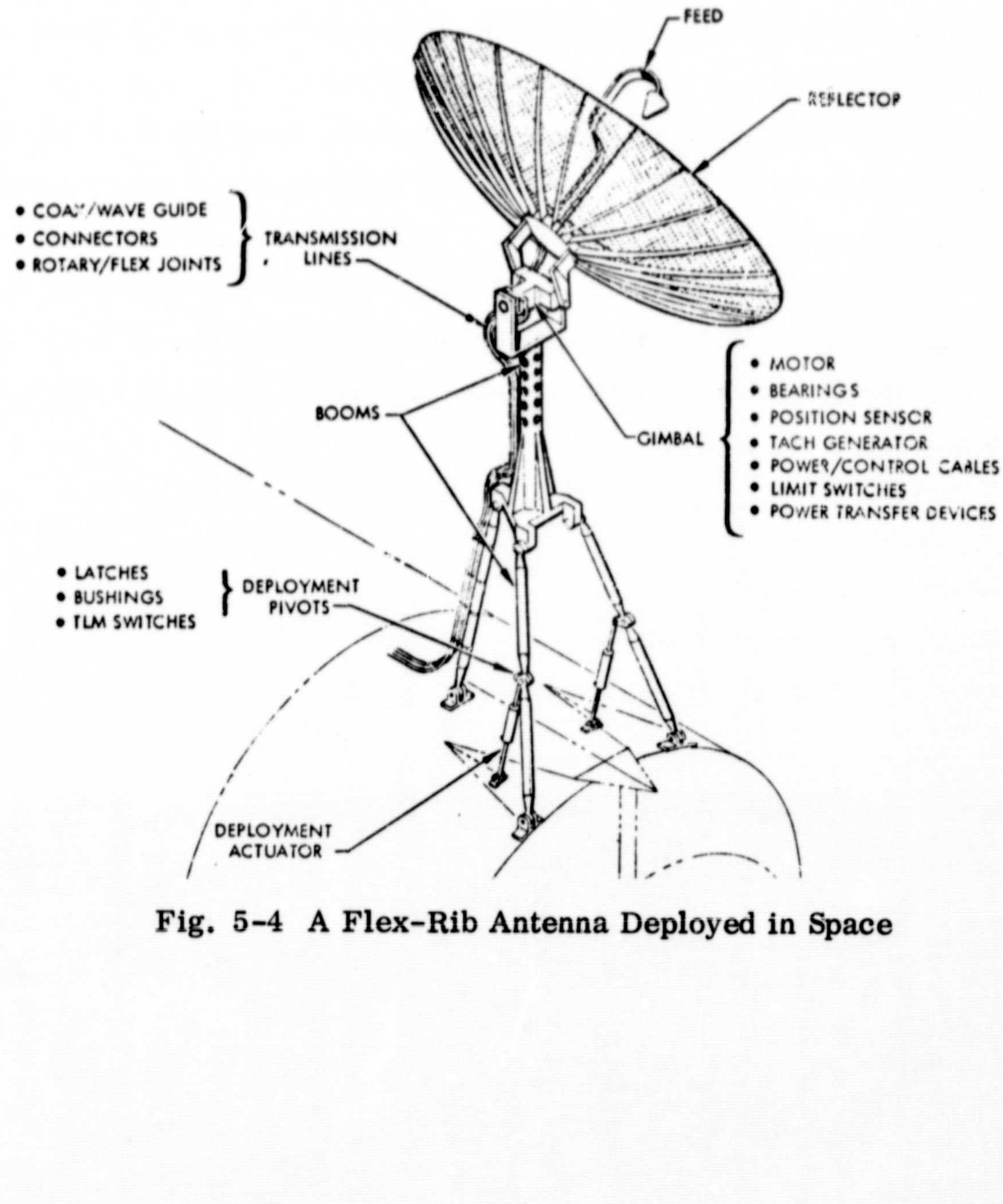


Fig. 5-4 A Flex-Rib Antenna Deployed in Space

5.2.16 RF Couplers

LMSC Drawing and Specification Numbers:

Nomenclature	Drawing	Specification
UHF Multicoupler, Type 14	1462232	1419745
UHF Multicoupler, 2 Channel	8100139	8100140

Vendor: Wavecom, Inc.

These units are capable of handling simultaneously the transmission of an RF signal and the reception of an RF signal to and from a common antenna. The transmission can be at any preselected frequency within the range of 2200 to 2300 MHz, and the received signal can be at any preselected frequency within the range of 1750 to 1850 MHz. The units weigh a maximum of 1.40 pounds.

5.2.17 RF Switches

LMSC Drawing and Specification Numbers:

Type	Drawing	Specification
12	1464600	1416635
13	1462070	1419551

Vendor: Transco Products, Inc.

These RF switches are both two-position units similar to the Type 14 RF switch used in the basic TT&C system. The Type 12 is a fail-safe (nonlatching) design, but differs from the Type 14 in that there is no separate pull-in coil. The Type 13 unit differs from both the Type 12 and Type 14 switches in that it is a latching switch and has separate commands for both positions.